

Supplementary Material for “Less is More: A Small-Scale Learning Particle Swarm Optimization for Large-Scale Optimization”

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TABLE S.I
EXPERIMENTAL COMPARISON RESULTS OF SSLPSO WITH THE TOP ALGORITHMS OF THE CEC2010 AND CEC2012 COMPETITIONS

FUN	SSLPSO	MA-SW-Chains	MOS	jDElsgo	CCGS
	Mean±Std	Mean±Std	Mean±Std	Mean±Std	Mean±Std
f_1	0.00E+00 ± 0.00E+00	2.10E-14 ± 1.99E-14 (+)	0.00E+00 ± 0.00E+00 (≈)	8.86E-20 ± 4.51E-20 (+)	1.83E-22 ± 3.68E-22 (+)
f_2	6.22E+02 ± 3.54E+01	8.10E+02 ± 5.88E+01 (+)	1.97E+02 ± 1.59E+01 (-)	1.25E-01 ± 3.45E-01 (-)	4.44E-02 ± 1.99E-01 (-)
f_3	4.53E-14 ± 4.62E-15	7.28E-13 ± 3.40E-13 (+)	1.12E+00 ± 1.00E+00 (+)	3.81E-12 ± 5.02E-12 (+)	1.91E-01 ± 4.49E-01 (+)
f_4	4.25E+10 ± 8.99E+09	3.53E+11 ± 3.12E+10 (+)	1.91E+10 ± 8.08E+09 (-)	8.06E+10 ± 3.08E+10 (+)	1.79E+12 ± 7.62E+11 (+)
f_5	2.78E+08 ± 8.90E+06	1.68E+08 ± 1.04E+08 (-)	6.81E+08 ± 1.42E+08 (+)	9.72E+07 ± 1.44E+07 (-)	1.97E+07 ± 4.69E+06 (-)
f_6	1.62E+01 ± 7.38E+00	8.14E+04 ± 2.84E+05 (+)	1.99E+07 ± 5.67E+04 (+)	1.70E-08 ± 4.03E-08 (-)	2.88E+06 ± 4.87E+05 (+)
f_7	1.26E-17 ± 1.76E-17	1.03E+02 ± 8.70E+01 (+)	0.00E+00 ± 0.00E+00 (-)	1.31E-02 ± 6.82E-02 (+)	1.37E+02 ± 1.16E+02 (+)
f_8	3.32E+03 ± 2.44E+03	1.41E+07 ± 3.68E+07 (+)	1.12E+06 ± 1.79E+06 (+)	3.15E+06 ± 3.27E+06 (+)	2.81E+07 ± 3.14E+07 (+)
f_9	5.29E+06 ± 5.44E+05	1.41E+07 ± 1.15E+06 (+)	8.78E+06 ± 1.01E+06 (+)	3.11E+07 ± 5.00E+06 (+)	5.53E+07 ± 9.60E+06 (+)
f_{10}	7.24E+02 ± 3.58E+01	2.07E+03 ± 1.44E+02 (+)	7.86E+03 ± 2.43E+02 (+)	2.64E+03 ± 3.19E+02 (+)	4.74E+03 ± 2.45E+03 (+)
f_{11}	1.83E+00 ± 5.59E+00	3.80E+01 ± 7.35E+00 (+)	1.99E+02 ± 4.52E-01 (+)	2.20E+01 ± 1.53E+01 (+)	2.99E+01 ± 3.98E+00 (+)
f_{12}	1.42E+02 ± 5.51E+01	3.62E-06 ± 5.92E-07 (-)	0.00E+00 ± 0.00E+00 (-)	1.21E+04 ± 2.04E+03 (+)	5.35E+03 ± 4.39E+02 (+)
f_{13}	1.18E+02 ± 5.86E+01	1.25E+03 ± 5.72E+02 (+)	1.36E+03 ± 9.37E+02 (+)	7.11E+02 ± 1.37E+02 (+)	1.51E+03 ± 6.94E+02 (+)
f_{14}	1.69E+07 ± 9.26E+05	3.11E+07 ± 1.93E+06 (+)	1.82E+07 ± 1.18E+06 (+)	1.69E+08 ± 2.08E+07 (+)	1.35E+08 ± 9.05E+06 (+)
f_{15}	1.02E+04 ± 6.48E+01	2.74E+03 ± 1.22E+02 (-)	1.54E+04 ± 5.36E+02 (+)	5.84E+03 ± 4.48E+02 (-)	1.74E+03 ± 8.94E+01 (-)
f_{16}	1.61E-13 ± 3.51E-15	9.98E+01 ± 1.40E+01 (+)	3.97E+02 ± 2.10E-01 (+)	1.44E+02 ± 3.43E+01 (+)	3.11E+01 ± 5.22E+00 (+)
f_{17}	8.82E+03 ± 1.93E+03	1.24E+00 ± 1.25E-01 (-)	4.66E-05 ± 6.24E-06 (-)	1.02E+05 ± 1.26E+04 (+)	1.48E+04 ± 1.02E+03 (+)
f_{18}	5.53E+02 ± 1.09E+02	1.30E+03 ± 4.36E+02 (+)	3.91E+03 ± 2.18E+03 (+)	1.85E+03 ± 3.18E+02 (+)	3.13E+03 ± 1.01E+03 (+)
f_{19}	1.28E+07 ± 1.10E+06	2.85E+05 ± 1.78E+04 (-)	3.41E+04 ± 2.63E+03 (-)	2.74E+05 ± 2.12E+04 (-)	5.93E+05 ± 4.21E+04 (-)
f_{20}	8.33E+02 ± 1.77E+01	1.07E+03 ± 7.29E+01 (+)	8.31E+02 ± 3.76E+02 (-)	1.53E+03 ± 1.32E+02 (+)	1.31E+03 ± 2.14E+02 (+)
+(SSLPSO is significantly better)		15	12	15	16
-(SSLPSO is significantly worse)		5	7	5	4
≈		0	1	0	0

TABLE S.II
OPTIMIZATION RESULTS ON THE 1000-D IEEE CEC2013 TEST SUITE WITH THE DIFFERENT FIXED VALUES OF NP AND φ

FUN	SSLPSO Mean±Std	$NP=1000, \varphi=0.7$ Mean±Std	$NP=1000, \varphi=0.6$ Mean±Std	$NP=1000, \varphi=0.4$ Mean±Std	$NP=1000, \varphi=0.2$ Mean±Std	$NP=800, \varphi=0.7$ Mean±Std	$NP=800, \varphi=0.6$ Mean±Std
F_1	0.00E+00 ± 0.00E+00	3.26E+07 ± 8.87E+05(+)	1.19E+04 ± 5.18E+02(+)	5.74E-22 ± 3.57E-23(+)	9.38E-23 ± 7.14E-24(+)	1.89E+07 ± 5.62E+05(+)	7.53E+02 ± 5.80E+01(+)
F_2	7.46E+02 ± 5.87E+01	1.26E+04 ± 1.09E+02(+)	1.11E+04 ± 7.97E+01(+)	5.95E+02 ± 5.12E+01(-)	6.33E+02 ± 2.66E+01(-)	1.25E+04 ± 1.25E+02(+)	1.10E+04 ± 8.57E+01(+)
F_3	2.16E+01 ± 6.83E-03	2.16E+01 ± 5.88E-03(≈)	2.16E+01 ± 6.82E-03(≈)	2.16E+01 ± 4.29E-03(≈)	2.16E+01 ± 6.78E-03(≈)	2.16E+01 ± 6.21E-03(≈)	2.16E+01 ± 5.98E-03(≈)
F_4	2.54E+08 ± 4.75E+07	1.20E+11 ± 1.50E+10(+)	2.16E+10 ± 4.51E+09(+)	1.22E+09 ± 3.51E+08(+)	9.57E+08 ± 2.17E+08(+)	9.80E+10 ± 1.42E+10(+)	2.03E+10 ± 3.28E+09(+)
F_5	4.81E+05 ± 7.62E+04	7.74E+06 ± 1.70E+05(+)	7.28E+06 ± 2.73E+05(+)	2.57E+06 ± 3.09E+06(≈)	2.02E+06 ± 2.72E+06(≈)	7.72E+06 ± 2.61E+05(+)	7.33E+06 ± 1.99E+05(+)
F_6	1.06E+06 ± 1.27E+03	1.06E+06 ± 1.29E+03(≈)	1.06E+06 ± 7.69E+02(≈)	1.06E+06 ± 1.62E+03(≈)	1.06E+06 ± 8.99E+02(≈)	1.06E+06 ± 9.30E+02(≈)	1.06E+06 ± 1.14E+03(≈)
F_7	3.01E+05 ± 3.84E+05	1.45E+09 ± 2.29E+08(+)	6.53E+08 ± 2.05E+08(+)	9.45E+05 ± 4.77E+05(+)	2.15E+05 ± 1.01E+05(≈)	1.43E+09 ± 2.93E+08(+)	6.04E+08 ± 2.41E+08(+)
F_8	1.27E+13 ± 2.19E+12	3.60E+14 ± 5.21E+13(+)	1.32E+14 ± 2.55E+13(+)	3.66E+13 ± 8.20E+12(+)	3.69E+13 ± 9.09E+12(+)	3.38E+14 ± 7.33E+13(+)	9.67E+13 ± 2.36E+13(+)
F_9	3.63E+07 ± 5.92E+06	5.82E+08 ± 1.50E+07(+)	5.46E+08 ± 1.47E+07(+)	5.09E+07 ± 8.56E+07(≈)	3.22E+07 ± 5.21E+06(-)	5.74E+08 ± 2.39E+07(+)	5.38E+08 ± 2.65E+07(+)
F_{10}	9.40E+07 ± 2.66E+05	9.40E+07 ± 2.37E+05(≈)	9.40E+07 ± 1.77E+05(≈)	9.41E+07 ± 2.11E+05(≈)	9.40E+07 ± 2.81E+05(≈)	9.40E+07 ± 2.48E+05(≈)	9.41E+07 ± 1.78E+05(≈)
F_{11}	4.29E+06 ± 2.80E+06	3.36E+10 ± 5.77E+09(+)	1.98E+10 ± 6.55E+09(+)	7.85E+08 ± 3.34E+08(+)	2.38E+08 ± 6.55E+07(+)	3.09E+10 ± 7.74E+09(+)	2.43E+10 ± 1.12E+10(+)
F_{12}	8.94E+02 ± 2.51E+01	1.68E+10 ± 8.76E+08(+)	2.14E+07 ± 2.10E+06(+)	9.78E+02 ± 1.33E+01(+)	9.76E+02 ± 1.56E+01(+)	1.32E+10 ± 7.51E+08(+)	3.34E+06 ± 4.61E+05(+)
F_{13}	3.49E+06 ± 3.19E+06	8.19E+10 ± 1.11E+10(+)	3.30E+10 ± 6.00E+09(+)	1.76E+09 ± 1.13E+09(+)	4.06E+08 ± 1.93E+08(+)	7.17E+10 ± 1.08E+10(+)	2.79E+10 ± 6.06E+09(+)
F_{14}	8.47E+06 ± 1.05E+05	1.92E+11 ± 3.98E+10(+)	2.37E+10 ± 1.11E+10(+)	2.42E+08 ± 9.51E+07(+)	5.84E+07 ± 1.97E+07(+)	1.38E+11 ± 4.37E+10(+)	2.22E+10 ± 1.33E+10(+)
F_{15}	4.70E+06 ± 7.95E+05	3.60E+08 ± 3.55E+07(+)	2.84E+08 ± 3.48E+07(+)	9.09E+07 ± 1.70E+07(+)	8.46E+07 ± 1.16E+07(+)	3.56E+08 ± 3.45E+07(+)	2.69E+08 ± 3.23E+07(+)
+ (SSLPSO is significantly better)		12	12	9	8	12	12
- (SSLPSO is significantly worse)		0	0	1	2	0	0
≈		3	3	5	5	3	3
FUN	$NP=800, \varphi=0.4$ Mean±Std	$NP=800, \varphi=0.2$ Mean±Std	$NP=600, \varphi=0.7$ Mean±Std	$NP=600, \varphi=0.6$ Mean±Std	$NP=600, \varphi=0.4$ Mean±Std	$NP=600, \varphi=0.2$ Mean±Std	$NP=400, \varphi=0.7$ Mean±Std
F_1	7.95E-25 ± 1.12E-25(+)	1.86E-25 ± 2.12E-26(+)	8.11E+06 ± 3.51E+05(+)	1.94E+00 ± 1.82E-01(+)	0.00E+00 ± 0.00E+00(≈)	0.00E+00 ± 0.00E+00(≈)	1.49E+06 ± 7.19E+04(+)
F_2	7.65E+02 ± 5.09E+01(≈)	7.71E+02 ± 4.47E+01(+)	1.23E+04 ± 7.22E+01(+)	1.08E+04 ± 6.30E+01(+)	1.07E+03 ± 9.83E+01(+)	1.11E+03 ± 7.31E+01(+)	1.20E+04 ± 1.03E+02(+)
F_3	2.16E+01 ± 5.88E-03(≈)	2.16E+01 ± 5.11E-03(≈)	2.16E+01 ± 4.63E-03(≈)	2.16E+01 ± 5.29E-03(≈)	2.16E+01 ± 5.92E-03(≈)	2.16E+01 ± 7.11E-03(≈)	2.16E+01 ± 7.06E-03(≈)
F_4	7.28E+08 ± 1.48E+08(+)	6.55E+08 ± 1.30E+08(+)	7.03E+10 ± 8.53E+09(+)	1.53E+10 ± 3.26E+09(+)	4.90E+08 ± 9.33E+07(+)	4.67E+08 ± 1.03E+08(+)	4.72E+10 ± 1.19E+10(+)
F_5	2.03E+06 ± 2.81E+06(≈)	7.83E+05 ± 1.17E+06(+)	7.60E+06 ± 2.68E+05(+)	7.21E+06 ± 2.68E+05(+)	5.73E+05 ± 9.51E+04(+)	6.38E+05 ± 9.22E+04(+)	7.54E+06 ± 3.39E+05(+)
F_6	1.06E+06 ± 1.02E+03(≈)	1.06E+06 ± 9.40E+02(≈)	1.06E+06 ± 1.13E+03(≈)	1.06E+06 ± 9.19E+02(≈)	1.06E+06 ± 9.70E+02(≈)	1.06E+06 ± 1.01E+03(≈)	1.06E+06 ± 1.07E+03(≈)
F_7	2.88E+05 ± 1.43E+05(≈)	1.29E+05 ± 5.29E+04(-)	1.18E+09 ± 2.99E+08(+)	5.22E+08 ± 2.46E+08(+)	2.85E+05 ± 1.34E+05(≈)	2.37E+05 ± 1.14E+05(≈)	1.08E+09 ± 3.55E+08(+)
F_8	2.99E+13 ± 9.03E+12(+)	2.85E+13 ± 5.91E+12(+)	2.41E+14 ± 8.09E+13(+)	5.75E+13 ± 1.19E+13(+)	1.77E+13 ± 6.50E+12(+)	2.11E+13 ± 8.72E+12(+)	1.32E+14 ± 3.86E+13(+)
F_9	4.97E+07 ± 8.81E+07(≈)	3.50E+07 ± 5.39E+06(≈)	5.68E+08 ± 1.96E+07(+)	3.63E+08 ± 2.10E+08(+)	4.09E+07 ± 5.78E+06(+)	4.43E+07 ± 6.95E+06(+)	5.59E+08 ± 2.51E+07(+)
F_{10}	9.39E+07 ± 2.84E+05(≈)	9.40E+07 ± 2.52E+05(≈)	9.41E+07 ± 2.17E+05(≈)	9.41E+07 ± 2.01E+05(≈)	9.41E+07 ± 1.92E+05(≈)	9.40E+07 ± 2.57E+05(≈)	9.41E+07 ± 2.11E+05(+)
F_{11}	3.08E+08 ± 9.09E+07(+)	1.19E+08 ± 3.28E+07(+)	2.82E+10 ± 6.30E+09(+)	3.00E+10 ± 1.94E+10(+)	9.90E+07 ± 3.89E+07(+)	3.72E+07 ± 1.50E+07(+)	3.44E+10 ± 1.69E+10(+)
F_{12}	9.69E+02 ± 3.69E+01(+)	9.65E+02 ± 3.38E+01(+)	9.44E+09 ± 6.42E+08(+)	7.65E+04 ± 1.18E+04(+)	9.18E+02 ± 2.44E+01(+)	9.62E+02 ± 5.75E+01(+)	4.23E+09 ± 3.39E+08(+)
F_{13}	5.09E+08 ± 3.18E+08(+)	9.47E+07 ± 6.43E+07(+)	6.42E+10 ± 9.94E+09(+)	2.56E+10 ± 6.66E+09(+)	4.88E+07 ± 4.86E+07(+)	1.68E+07 ± 3.94E+07(+)	5.06E+10 ± 7.77E+09(+)
F_{14}	5.91E+07 ± 1.56E+07(+)	3.38E+07 ± 7.88E+06(+)	9.60E+10 ± 4.19E+10(+)	2.55E+10 ± 1.04E+10(+)	2.97E+07 ± 6.20E+06(+)	2.19E+07 ± 3.60E+06(+)	5.27E+10 ± 2.82E+10(+)
F_{15}	6.48E+07 ± 1.61E+07(+)	5.50E+07 ± 1.12E+07(+)	3.38E+08 ± 3.98E+07(+)	2.42E+08 ± 2.44E+07(+)	2.67E+07 ± 1.37E+07(+)	1.25E+07 ± 7.55E+06(+)	3.12E+08 ± 3.30E+07(+)
+	8	10	12	12	10	10	13
-	0	1	0	0	0	0	0
≈	7	4	3	3	5	5	2
FUN	$NP=400, \varphi=0.6$ Mean±Std	$NP=400, \varphi=0.4$ Mean±Std	$NP=400, \varphi=0.2$ Mean±Std	$NP=200, \varphi=0.7$ Mean±Std	$NP=200, \varphi=0.6$ Mean±Std	$NP=200, \varphi=0.4$ Mean±Std	$NP=200, \varphi=0.2$ Mean±Std
F_1	5.57E-08 ± 2.86E-08(+)	0.00E+00 ± 0.00E+00(≈)	1.83E-25 ± 1.00E-24(≈)	4.29E+03 ± 1.28E+04(+)	8.53E-20 ± 3.91E-19(+)	1.64E+07 ± 2.47E+07(+)	1.14E+06 ± 1.73E+06(+)
F_2	1.04E+04 ± 1.26E+02(+)	1.82E+03 ± 1.30E+02(+)	1.93E+03 ± 1.41E+02(+)	1.10E+04 ± 1.44E+02(+)	1.99E+03 ± 1.64E+02(+)	4.76E+03 ± 3.01E+02(+)	5.29E+03 ± 3.53E+02(+)
F_3	2.16E+01 ± 7.11E-03(≈)	2.16E+01 ± 5.36E-03(≈)	2.16E+01 ± 5.85E-03(≈)	2.16E+01 ± 7.74E-03(-)	2.16E+01 ± 7.50E-03(≈)	2.16E+01 ± 4.41E-03(≈)	2.16E+01 ± 7.31E-03(≈)
F_4	8.44E+09 ± 2.26E+09(+)	4.12E+08 ± 9.08E+07(+)	4.14E+08 ± 1.07E+08(+)	1.33E+10 ± 4.64E+09(+)	1.63E+09 ± 4.64E+08(+)	1.58E+09 ± 8.40E+08(+)	1.41E+09 ± 5.86E+08(+)
F_5	5.19E+06 ± 3.01E+06(+)	7.15E+05 ± 1.35E+05(+)	8.09E+05 ± 1.12E+05(+)	4.43E+06 ± 3.28E+06(+)	8.96E+05 ± 2.20E+05(+)	1.27E+06 ± 2.32E+05(+)	1.36E+06 ± 2.75E+05(+)
F_6	1.06E+06 ± 1.33E+03(≈)	1.06E+06 ± 1.10E+03(≈)	1.06E+06 ± 1.26E+03(≈)	1.06E+06 ± 9.36E+02(≈)	1.06E+06 ± 7.80E+02(≈)	1.06E+06 ± 1.08E+03(≈)	1.06E+06 ± 9.89E+02(≈)
F_7	1.94E+08 ± 1.11E+08(+)	2.50E+06 ± 4.50E+06(+)	1.69E+06 ± 7.55E+05(+)	6.00E+08 ± 3.92E+08(+)	5.05E+06 ± 1.72E+06(+)	1.15E+07 ± 7.22E+06(+)	1.10E+07 ± 1.49E+07(+)
F_8	4.38E+13 ± 1.40E+13(+)	1.53E+13 ± 4.51E+12(+)	1.49E+13 ± 4.80E+12(+)	3.71E+13 ± 1.41E+13(+)	9.89E+12 ± 3.60E+12(-)	1.13E+13 ± 2.63E+13(-)	2.07E+13 ± 4.59E+13(≈)
F_9	1.40E+08 ± 1.35E+08(+)	5.81E+07 ± 1.28E+07(+)	6.07E+07 ± 1.01E+07(+)	1.04E+08 ± 1.34E+07(+)	6.54E+07 ± 1.22E+07(+)	1.20E+08 ± 1.94E+07(+)	1.41E+08 ± 1.94E+07(+)
F_{10}	9.40E+07 ± 2.82E+05(≈)	9.41E+07 ± 2.43E+05(≈)	9.41E+07 ± 2.54E+05(≈)	9.41E+07 ± 2.15E+05(+)	9.40E+07 ± 3.19E+05(≈)	9.40E+07 ± 2.17E+05(≈)	9.40E+07 ± 2.54E+05(≈)
F_{11}	3.12E+10 ± 2.30E+10(+)	8.69E+06 ± 4.34E+06(+)	1.36E+07 ± 1.44E+07(+)	5.55E+10 ± 3.38E+10(+)	2.82E+08 ± 1.33E+08(+)	1.24E+08 ± 2.99E+08(+)	1.15E+08 ± 8.35E+07(+)
F_{12}	1.07E+03 ± 1.12E+02(+)	8.78E+02 ± 4.65E+01(≈)	9.01E+02 ± 8.05E+01(≈)	1.79E+07 ± 1.90E+07(+)	1.23E+03 ± 9.93E+01(+)	2.55E+03 ± 6.57E-03(-)	9.04E+03 ± 2.51E+04(+)
F_{13}	1.67E+10 ± 5.29E+09(+)	8.28E+06 ± 5.29E+06(+)	9.16E+06 ± 7.87E+06(+)	2.26E+10 ± 6.48E+09(+)	4.51E+08 ± 2.68E+08(+)	1.88E+08 ± 3.57E+08(+)	1.51E+08 ± 1.37E+08(+)
F_{14}	2.85E+10 ± 1.43E+10(+)	3.33E+07 ± 7.51E+07(+)	2.67E+07 ± 1.98E+07(+)	6.36E+10 ± 5.23E+10(+)	1.50E+08 ± 1.80E+08(+)	5.40E+08 ± 1.29E+09(+)	3.79E+08 ± 5.90E+08(+)
F_{15}	1.84E+08 ± 2.35E+07(+)	3.95E+06 ± 4.12E+05(-)	2.94E+06 ± 4.34E+05(-)	2.21E+08 ± 4.55E+07(+)	5.22E+07 ± 7.85E+06(+)	6.32E+06 ± 1.06E+06(+)	8.33E+06 ± 1.53E+06(+)
+	12	9	9	13	11	10	11
-	0	1	1	1	1	2	0
≈	3	5	5	1	3	3	4

TABLE S.III
OPTIMIZATION RESULTS OF DIFFERENT UPPER AND LOWER BOUNDS OF NP ON THE 1000-D IEEE CEC2013 TEST SUITE

FUN	SSLPSO ($NP=1000\sim 200$)	$NP=1200\sim 1000$	$NP=1200\sim 800$	$NP=1200\sim 600$	$NP=1200\sim 400$
	Mean \pm Std	Mean \pm Std	Mean \pm Std	Mean \pm Std	Mean \pm Std
F_1	0.00E+00 \pm 0.00E+00	9.07E-23 \pm 5.60E-24(+)	1.84E-24 \pm 2.12E-25(+)	0.00E+00 \pm 0.00E+00 (\approx)	0.00E+00 \pm 0.00E+00 (\approx)
F_2	7.46E+02 \pm 5.87E+01	5.78E+02 \pm 3.75E+01 (-)	5.93E+02 \pm 3.50E+01(-)	6.13E+02 \pm 3.64E+01(-)	6.45E+02 \pm 5.87E+01(-)
F_3	2.16E+01 \pm 6.83E-03	2.16E+01 \pm 5.17E-03 (\approx)	2.16E+01 \pm 6.07E-03 (\approx)	2.16E+01 \pm 6.62E-03 (\approx)	2.16E+01 \pm 5.75E-03 (\approx)
F_4	2.54E+08 \pm 4.75E+07	8.53E+08 \pm 1.72E+08(+)	6.66E+08 \pm 1.02E+08(+)	4.85E+08 \pm 6.87E+07(+)	4.06E+08 \pm 6.27E+07(+)
F_5	4.81E+05 \pm 7.62E+04	3.65E+06 \pm 3.31E+06(\approx)	3.58E+06 \pm 3.14E+06(+)	2.57E+06 \pm 3.11E+06(\approx)	2.36E+06 \pm 2.98E+06(\approx)
F_6	1.06E+06 \pm 1.27E+03	1.06E+06 \pm 9.53E+02 (\approx)	1.06E+06 \pm 1.18E+03 (\approx)	1.06E+06 \pm 1.12E+03 (\approx)	1.06E+06 \pm 1.61E+03 (\approx)
F_7	3.01E+05 \pm 3.84E+05	1.66E+05 \pm 7.51E+04(-)	9.32E+04 \pm 4.30E+04(-)	7.48E+04 \pm 4.33E+04(-)	7.29E+04 \pm 5.49E+04 (-)
F_8	1.27E+13 \pm 2.19E+12	3.53E+13 \pm 7.22E+12(+)	3.32E+13 \pm 8.12E+12(+)	2.24E+13 \pm 7.66E+12(+)	1.77E+13 \pm 5.48E+12(+)
F_9	3.63E+07 \pm 5.92E+06	4.64E+07 \pm 8.55E+07(-)	7.99E+07 \pm 1.45E+08(-)	4.76E+07 \pm 9.00E+07(-)	3.41E+07 \pm 1.13E+07(-)
F_{10}	9.40E+07 \pm 2.66E+05	9.40E+07 \pm 1.93E+05(\approx)	9.40E+07 \pm 1.99E+05(\approx)	9.40E+07 \pm 1.86E+05(\approx)	9.41E+07 \pm 2.47E+05(\approx)
F_{11}	4.29E+06 \pm 2.80E+06	2.16E+08 \pm 7.15E+07(+)	1.33E+08 \pm 4.50E+07(+)	5.24E+07 \pm 2.41E+07(+)	1.36E+07 \pm 7.60E+06(+)
F_{12}	8.94E+02 \pm 2.51E+01	9.70E+02 \pm 1.50E+01(+)	9.58E+02 \pm 1.47E+01(+)	9.15E+02 \pm 1.27E+01(+)	9.08E+02 \pm 1.73E+01(+)
F_{13}	3.49E+06 \pm 3.19E+06	3.24E+08 \pm 1.44E+08(+)	1.30E+08 \pm 6.97E+07(+)	2.63E+07 \pm 1.61E+07(+)	6.78E+06 \pm 2.50E+06(+)
F_{14}	8.47E+06 \pm 1.05E+06	4.16E+07 \pm 8.44E+06(+)	2.73E+07 \pm 4.52E+06(+)	1.74E+07 \pm 2.82E+06(+)	1.15E+07 \pm 2.30E+06(+)
F_{15}	4.70E+06 \pm 7.95E+05	7.65E+07 \pm 2.31E+07(+)	6.42E+07 \pm 2.71E+07(+)	3.31E+07 \pm 1.78E+07(+)	1.09E+07 \pm 7.31E+06(+)
+(SSLPSO is significantly better)		8	9	7	7
-(SSLPSO is significantly worse)		3	3	3	3
\approx		4	3	5	5
FUN	$NP=1200\sim 200$	$NP=1000\sim 800$	$NP=1000\sim 600$	$NP=1000\sim 400$	$NP=800\sim 600$
	Mean \pm Std	Mean \pm Std	Mean \pm Std	Mean \pm Std	Mean \pm Std
F_1	7.00E-29 \pm 3.84E-28(\approx)	1.76E-25 \pm 2.85E-26(+)	0.00E+00 \pm 0.00E+00 (\approx)	0.00E+00 \pm 0.00E+00 (\approx)	0.00E+00 \pm 0.00E+00 (\approx)
F_2	6.46E+02 \pm 3.09E+01(-)	6.67E+02 \pm 5.58E+01(-)	6.84E+02 \pm 4.85E+01(-)	7.26E+02 \pm 4.69E+01(\approx)	8.17E+02 \pm 6.56E+01(+)
F_3	2.16E+01 \pm 4.24E-03 (\approx)	2.16E+01 \pm 5.92E-03 (\approx)	2.16E+01 \pm 7.01E-03 (\approx)	2.16E+01 \pm 5.83E-03 (\approx)	2.16E+01 \pm 6.02E-03 (\approx)
F_4	2.81E+08 \pm 5.21E+07(+)	5.74E+08 \pm 9.33E+07(+)	4.67E+08 \pm 5.85E+07(+)	3.48E+08 \pm 6.30E+07(+)	4.32E+08 \pm 5.64E+07(+)
F_5	2.40E+06 \pm 3.00E+06(\approx)	2.39E+06 \pm 2.99E+06(\approx)	2.84E+06 \pm 3.20E+06(\approx)	1.12E+06 \pm 1.97E+06(\approx)	7.30E+05 \pm 1.22E+06(\approx)
F_6	1.06E+06 \pm 1.34E+03 (\approx)	1.06E+06 \pm 9.82E+02 (\approx)	1.06E+06 \pm 9.46E+02 (\approx)	1.06E+06 \pm 1.10E+03 (\approx)	1.06E+06 \pm 1.09E+03 (\approx)
F_7	1.60E+05 \pm 1.02E+05(-)	1.12E+05 \pm 6.60E+04(-)	9.09E+04 \pm 7.47E+04(-)	1.19E+05 \pm 7.75E+04(-)	1.66E+05 \pm 1.37E+05(-)
F_8	1.47E+13 \pm 3.17E+12(+)	2.94E+13 \pm 5.90E+12(+)	2.41E+13 \pm 9.14E+12(+)	1.78E+13 \pm 4.69E+12(+)	2.11E+13 \pm 6.74E+12(+)
F_9	3.37E+07 \pm 6.02E+06(\approx)	3.23E+07 \pm 5.06E+06 (-)	3.31E+07 \pm 4.49E+06(-)	3.38E+07 \pm 4.60E+06(\approx)	3.68E+07 \pm 6.39E+06(\approx)
F_{10}	9.40E+07 \pm 2.16E+05(\approx)	9.41E+07 \pm 2.51E+05(\approx)	9.40E+07 \pm 3.32E+05(\approx)	9.39E+07 \pm 2.76E+05 (\approx)	9.40E+07 \pm 2.35E+05(\approx)
F_{11}	5.22E+06 \pm 3.03E+06(\approx)	1.13E+08 \pm 4.80E+07(+)	4.17E+07 \pm 1.98E+07(+)	8.01E+06 \pm 3.71E+06(+)	2.57E+07 \pm 1.41E+07(+)
F_{12}	9.03E+02 \pm 2.51E+01(\approx)	9.14E+02 \pm 1.01E+01(+)	9.13E+02 \pm 1.46E+01(+)	9.01E+02 \pm 1.94E+01(\approx)	9.17E+02 \pm 3.63E+01(+)
F_{13}	2.96E+06 \pm 1.63E+06 (\approx)	8.34E+07 \pm 4.35E+07(+)	1.69E+07 \pm 8.31E+06(+)	5.70E+06 \pm 2.59E+06(+)	1.29E+07 \pm 8.20E+06(+)
F_{14}	8.33E+06 \pm 1.11E+06 (\approx)	2.46E+07 \pm 3.64E+06(+)	1.74E+07 \pm 3.24E+06(+)	1.15E+07 \pm 1.56E+06(+)	1.65E+07 \pm 2.17E+06(+)
F_{15}	5.77E+06 \pm 1.43E+06(+)	4.81E+07 \pm 1.76E+07(+)	2.45E+07 \pm 1.54E+07(+)	7.38E+06 \pm 3.31E+06(+)	1.38E+07 \pm 8.21E+06(+)
+	3	8	7	6	8
-	2	3	3	1	1
\approx	10	4	5	8	6
FUN	$NP=800\sim 400$	$NP=800\sim 200$	$NP=600\sim 400$	$NP=600\sim 200$	$NP=400\sim 200$
	Mean \pm Std	Mean \pm Std	Mean \pm Std	Mean \pm Std	Mean \pm Std
F_1	0.00E+00 \pm 0.00E+00 (\approx)	1.18E-28 \pm 6.45E-28(\approx)	0.00E+00 \pm 0.00E+00 (\approx)	0.00E+00 \pm 0.00E+00 (\approx)	1.16E-25 \pm 3.44E-25(+)
F_2	8.53E+02 \pm 4.83E+01(+)	9.35E+02 \pm 8.41E+01(+)	1.20E+03 \pm 1.01E+02(+)	1.24E+03 \pm 9.03E+01(+)	1.98E+03 \pm 1.51E+02(+)
F_3	2.16E+01 \pm 7.33E-03 (\approx)	2.16E+01 \pm 5.43E-03 (\approx)	2.16E+01 \pm 6.07E-03 (\approx)	2.16E+01 \pm 4.56E-03 (\approx)	2.16E+01 \pm 4.63E-03 (\approx)
F_4	3.27E+08 \pm 5.81E+07(+)	2.59E+08 \pm 5.67E+07(\approx)	3.06E+08 \pm 7.22E+07(+)	3.01E+08 \pm 1.35E+08(\approx)	3.88E+08 \pm 1.29E+08(+)
F_5	1.58E+06 \pm 2.41E+06(+)	1.23E+06 \pm 2.03E+06(+)	6.19E+05 \pm 1.13E+05(+)	8.43E+05 \pm 1.18E+06(+)	9.82E+05 \pm 1.25E+06(+)
F_6	1.06E+06 \pm 9.36E+02 (\approx)	1.06E+06 \pm 1.48E+03 (\approx)	1.06E+06 \pm 9.99E+02 (\approx)	1.06E+06 \pm 1.00E+03 (\approx)	1.06E+06 \pm 1.02E+03 (\approx)
F_7	2.99E+05 \pm 1.54E+05(\approx)	5.32E+05 \pm 2.38E+05(+)	6.63E+05 \pm 2.33E+05(+)	1.22E+06 \pm 7.44E+05(+)	2.79E+06 \pm 9.84E+05(+)
F_8	1.75E+13 \pm 5.81E+12(+)	1.25E+13 \pm 2.74E+12(\approx)	1.57E+13 \pm 6.14E+12(+)	1.19E+13 \pm 3.59E+12(\approx)	9.55E+12 \pm 4.26E+12 (-)
F_9	3.83E+07 \pm 6.73E+06(\approx)	3.99E+07 \pm 7.46E+06(\approx)	4.21E+07 \pm 6.49E+06(+)	4.55E+07 \pm 9.01E+06(+)	6.28E+07 \pm 1.17E+07(+)
F_{10}	9.41E+07 \pm 1.83E+05(\approx)	9.40E+07 \pm 2.76E+05(\approx)	9.40E+07 \pm 2.19E+05(\approx)	9.40E+07 \pm 2.56E+05(\approx)	9.40E+07 \pm 2.10E+05(\approx)
F_{11}	6.95E+06 \pm 5.29E+06(+)	4.30E+06 \pm 2.12E+06(\approx)	5.29E+06 \pm 2.19E+06(+)	4.88E+06 \pm 2.48E+06(\approx)	1.15E+07 \pm 6.78E+06(+)
F_{12}	8.94E+02 \pm 1.96E+01(\approx)	8.86E+02 \pm 4.00E+01 (\approx)	8.90E+02 \pm 3.02E+01(\approx)	8.97E+02 \pm 3.32E+01(\approx)	9.40E+02 \pm 8.35E+01(+)
F_{13}	4.27E+06 \pm 1.70E+06(+)	4.83E+06 \pm 4.67E+06(\approx)	5.39E+06 \pm 4.89E+06(+)	5.16E+06 \pm 4.91E+06(\approx)	2.23E+07 \pm 3.52E+07(+)
F_{14}	1.19E+07 \pm 2.62E+06(+)	9.84E+06 \pm 1.38E+06(+)	1.17E+07 \pm 2.35E+06(+)	2.50E+07 \pm 5.77E+07(+)	5.20E+07 \pm 9.28E+07(+)
F_{15}	5.23E+06 \pm 1.17E+06(\approx)	4.68E+06 \pm 6.67E+05(\approx)	4.03E+06 \pm 3.09E+05 (-)	4.53E+06 \pm 7.01E+05(\approx)	5.21E+06 \pm 7.44E+05(+)
+	7	4	9	5	11
-	0	0	1	0	1
\approx	8	11	5	10	3

TABLE S.IV
OPTIMIZATION RESULTS OF DIFFERENT UPPER AND LOWER BOUNDS OF φ ON THE 1000-D IEEE CEC2013 TEST SUITE

FUN	SSLP SO ($\varphi=0.4\sim 0.2$)	$\varphi=0.7\sim 0.6$	$\varphi=0.7\sim 0.5$	$\varphi=0.7\sim 0.4$	$\varphi=0.7\sim 0.3$
	Mean \pm Std	Mean \pm Std	Mean \pm Std	Mean \pm Std	Mean \pm Std
F_1	0.00E+00 \pm 0.00E+00	4.30E-05 \pm 8.40E-06(+)	5.39E-21 \pm 1.65E-21(+)	2.13E-25 \pm 3.77E-25(+)	1.25E-25 \pm 4.70E-25(+)
F_2	7.46E+02 \pm 5.87E+01	9.83E+03 \pm 5.42E+02(+)	6.99E+02 \pm 3.29E+01(-)	6.40E+02 \pm 3.45E+01(-)	6.04E+02 \pm 2.18E+01(-)
F_3	2.16E+01 \pm 6.83E-03	2.16E+01 \pm 7.58E-03(-)	2.16E+01 \pm 5.24E-03(-)	2.16E+01 \pm 7.05E-03(\approx)	2.16E+01 \pm 6.81E-03(-)
F_4	2.54E+08 \pm 4.75E+07	9.80E+09 \pm 1.74E+09(+)	2.81E+09 \pm 4.21E+08(+)	6.95E+08 \pm 9.83E+07(+)	4.54E+08 \pm 7.26E+07(+)
F_5	4.81E+05 \pm 7.62E+04	7.45E+06 \pm 3.09E+05(+)	7.46E+06 \pm 1.84E+05(+)	7.36E+06 \pm 2.43E+05(+)	7.35E+06 \pm 2.00E+05(+)
F_6	1.06E+06 \pm 1.27E+03	1.06E+06 \pm 8.70E+02(\approx)	1.06E+06 \pm 1.03E+03(\approx)	1.06E+06 \pm 1.03E+03(\approx)	1.06E+06 \pm 1.37E+03(\approx)
F_7	3.01E+05 \pm 3.84E+05	1.81E+08 \pm 1.16E+08(+)	2.63E+06 \pm 1.29E+06(+)	4.83E+05 \pm 2.37E+05(+)	3.82E+05 \pm 2.12E+05(+)
F_8	1.27E+13 \pm 2.19E+12	4.42E+13 \pm 9.86E+12(+)	3.06E+13 \pm 8.96E+12(+)	2.16E+13 \pm 7.56E+12(+)	1.46E+13 \pm 4.43E+12(\approx)
F_9	3.63E+07 \pm 5.92E+06	5.53E+08 \pm 1.90E+07(+)	5.44E+08 \pm 1.41E+07(+)	4.13E+08 \pm 2.12E+08(+)	2.54E+08 \pm 2.46E+08(+)
F_{10}	9.40E+07 \pm 2.66E+05	9.40E+07 \pm 2.32E+05(\approx)	9.41E+07 \pm 2.55E+05(\approx)	9.41E+07 \pm 2.33E+05(\approx)	9.40E+07 \pm 2.32E+05(\approx)
F_{11}	4.29E+06 \pm 2.80E+06	1.07E+10 \pm 2.62E+09(+)	1.29E+09 \pm 1.26E+09(+)	6.46E+07 \pm 2.13E+07(+)	2.31E+07 \pm 8.52E+06(+)
F_{12}	8.94E+02 \pm 2.51E+01	1.33E+03 \pm 1.01E+02(+)	1.03E+03 \pm 2.49E+01(+)	9.85E+02 \pm 2.29E+01(+)	9.43E+02 \pm 2.83E+01(+)
F_{13}	3.49E+06 \pm 3.19E+06	1.87E+10 \pm 9.13E+09(+)	9.91E+08 \pm 4.75E+08(+)	6.44E+07 \pm 3.24E+07(+)	1.91E+07 \pm 1.01E+07(+)
F_{14}	8.47E+06 \pm 1.05E+06	8.93E+09 \pm 3.86E+09(+)	2.98E+08 \pm 2.53E+08(+)	2.13E+07 \pm 3.73E+06(+)	1.40E+07 \pm 1.69E+06(+)
F_{15}	4.70E+06 \pm 7.95E+05	3.37E+08 \pm 3.24E+07(+)	3.16E+08 \pm 2.64E+07(+)	3.20E+08 \pm 3.43E+07(+)	3.02E+08 \pm 3.86E+07(+)
+(SSLP SO is significantly better)		12	11	11	10
-(SSLP SO is significantly worse)		1	2	1	2
\approx		2	2	3	3
FUN	$\varphi=0.7\sim 0.2$	$\varphi=0.6\sim 0.5$	$\varphi=0.6\sim 0.4$	$\varphi=0.6\sim 0.3$	$\varphi=0.6\sim 0.2$
	Mean \pm Std	Mean \pm Std	Mean \pm Std	Mean \pm Std	Mean \pm Std
F_1	2.81E-26 \pm 8.64E-26(+)	8.80E-24 \pm 6.54E-24(+)	3.45E-26 \pm 9.36E-26(+)	5.32E-29 \pm 2.01E-28(+)	2.21E-26 \pm 1.21E-25(\approx)
F_2	5.84E+02 \pm 2.06E+01(-)	6.96E+02 \pm 4.07E+01(-)	6.30E+02 \pm 3.85E+01(-)	6.07E+02 \pm 2.60E+01(-)	5.93E+02 \pm 3.23E+01(-)
F_3	2.16E+01 \pm 4.57E-03(\approx)	2.16E+01 \pm 5.78E-03(\approx)	2.16E+01 \pm 4.84E-03(\approx)	2.16E+01 \pm 4.82E-03(\approx)	2.16E+01 \pm 6.37E-03(\approx)
F_4	4.15E+08 \pm 7.30E+07(+)	1.79E+09 \pm 5.15E+08(+)	5.24E+08 \pm 8.63E+07(+)	3.92E+08 \pm 6.45E+07(+)	3.31E+08 \pm 5.60E+07(+)
F_5	7.19E+06 \pm 3.07E+05(+)	7.14E+06 \pm 2.19E+05(+)	7.15E+06 \pm 3.19E+05(+)	6.89E+06 \pm 1.23E+06(+)	6.11E+06 \pm 2.28E+06(+)
F_6	1.06E+06 \pm 9.07E+02(\approx)	1.06E+06 \pm 7.77E+02(\approx)	1.06E+06 \pm 1.10E+03(\approx)	1.06E+06 \pm 1.31E+03(\approx)	1.06E+06 \pm 1.18E+03(\approx)
F_7	3.23E+05 \pm 1.63E+05(+)	1.00E+06 \pm 4.26E+05(+)	4.08E+05 \pm 2.21E+05(+)	3.52E+05 \pm 1.49E+05(+)	3.39E+05 \pm 1.94E+05(\approx)
F_8	1.59E+13 \pm 4.57E+12(+)	2.32E+13 \pm 9.95E+12(+)	1.46E+13 \pm 2.94E+12(+)	1.41E+13 \pm 3.55E+12(\approx)	1.51E+13 \pm 4.55E+12(+)
F_9	2.77E+08 \pm 2.44E+08(+)	2.44E+08 \pm 2.43E+08(+)	1.49E+08 \pm 2.09E+08(\approx)	1.82E+08 \pm 2.22E+08(+)	1.68E+08 \pm 2.12E+08(+)
F_{10}	9.40E+07 \pm 2.13E+05(\approx)	9.40E+07 \pm 1.82E+05(\approx)	9.40E+07 \pm 2.59E+05(\approx)	9.40E+07 \pm 2.68E+05(\approx)	9.41E+07 \pm 1.73E+05(+)
F_{11}	1.45E+07 \pm 7.07E+06(+)	5.38E+08 \pm 7.10E+08(+)	4.50E+07 \pm 2.20E+07(+)	1.43E+07 \pm 7.24E+06(+)	1.09E+07 \pm 6.50E+06(+)
F_{12}	9.26E+02 \pm 3.38E+01(+)	1.00E+03 \pm 1.36E+01(+)	9.23E+02 \pm 1.81E+01(+)	9.10E+02 \pm 3.54E+00(+)	9.12E+02 \pm 1.42E+01(+)
F_{13}	1.26E+07 \pm 8.27E+06(+)	6.07E+08 \pm 3.00E+08(+)	2.99E+07 \pm 1.80E+07(+)	1.25E+07 \pm 8.57E+06(+)	8.88E+06 \pm 6.70E+06(+)
F_{14}	1.19E+07 \pm 3.00E+06(+)	9.18E+07 \pm 8.28E+07(+)	1.47E+07 \pm 2.19E+06(+)	1.09E+07 \pm 1.43E+06(+)	9.25E+06 \pm 1.38E+06(+)
F_{15}	2.94E+08 \pm 3.86E+07(+)	2.19E+08 \pm 4.73E+07(+)	2.07E+08 \pm 5.03E+07(+)	1.34E+08 \pm 8.66E+07(+)	1.04E+08 \pm 9.56E+07(+)
+	11	11	10	10	10
-	1	1	1	1	1
\approx	3	3	4	4	4
FUN	$\varphi=0.5\sim 0.4$	$\varphi=0.5\sim 0.3$	$\varphi=0.5\sim 0.2$	$\varphi=0.4\sim 0.3$	$\varphi=0.3\sim 0.2$
	Mean \pm Std	Mean \pm Std	Mean \pm Std	Mean \pm Std	Mean \pm Std
F_1	0.00E+00 \pm 0.00E+00(\approx)	9.82E-28 \pm 5.38E-27(\approx)	0.00E+00 \pm 0.00E+00(\approx)	1.48E-29 \pm 5.65E-29(\approx)	1.28E-30 \pm 7.00E-30(\approx)
F_2	6.43E+02 \pm 3.97E+01(-)	6.39E+02 \pm 4.75E+01(-)	6.45E+02 \pm 5.81E+01(-)	7.35E+02 \pm 4.26E+01(\approx)	8.14E+02 \pm 4.95E+01(+)
F_3	2.16E+01 \pm 6.86E-03(\approx)	2.16E+01 \pm 8.03E-03(\approx)	2.16E+01 \pm 5.64E-03(\approx)	2.16E+01 \pm 6.28E-03(\approx)	2.16E+01 \pm 5.62E-03(\approx)
F_4	3.69E+08 \pm 5.45E+07(+)	3.01E+08 \pm 6.20E+07(+)	3.01E+08 \pm 6.02E+07(+)	2.51E+08 \pm 4.85E+07(\approx)	2.77E+08 \pm 6.47E+07(\approx)
F_5	3.93E+06 \pm 3.31E+06(+)	4.15E+06 \pm 3.30E+06(+)	3.70E+06 \pm 3.31E+06(+)	1.34E+06 \pm 2.23E+06(\approx)	7.53E+05 \pm 1.22E+06(\approx)
F_6	1.06E+06 \pm 1.07E+03(\approx)	1.06E+06 \pm 1.70E+03(\approx)	1.06E+06 \pm 1.32E+03(\approx)	1.06E+06 \pm 9.81E+02(\approx)	1.06E+06 \pm 1.16E+03(\approx)
F_7	1.78E+05 \pm 1.17E+05(-)	3.06E+05 \pm 2.02E+05(\approx)	2.93E+05 \pm 1.80E+05(\approx)	2.93E+05 \pm 3.88E+05(\approx)	1.86E+05 \pm 9.38E+04(\approx)
F_8	1.46E+13 \pm 3.16E+12(+)	1.28E+13 \pm 2.49E+12(\approx)	1.28E+13 \pm 2.72E+12(\approx)	1.39E+13 \pm 3.38E+12(\approx)	1.31E+13 \pm 2.20E+12(\approx)
F_9	6.78E+07 \pm 1.21E+08(\approx)	6.70E+07 \pm 1.18E+08(\approx)	6.57E+07 \pm 1.18E+08(\approx)	5.17E+07 \pm 8.87E+07(\approx)	3.69E+07 \pm 5.34E+06(\approx)
F_{10}	9.41E+07 \pm 1.70E+05(\approx)	9.40E+07 \pm 2.61E+05(\approx)	9.40E+07 \pm 2.27E+05(\approx)	9.40E+07 \pm 1.59E+05(\approx)	9.41E+07 \pm 2.11E+05(+)
F_{11}	1.86E+07 \pm 8.68E+06(+)	1.02E+07 \pm 6.49E+06(+)	6.61E+06 \pm 5.27E+06(+)	4.32E+06 \pm 3.16E+06(\approx)	3.50E+06 \pm 1.53E+06(\approx)
F_{12}	9.12E+02 \pm 1.50E+01(+)	9.06E+02 \pm 1.88E+01(+)	8.99E+02 \pm 1.91E+01(\approx)	8.86E+02 \pm 3.43E+01(\approx)	8.95E+02 \pm 3.32E+01(\approx)
F_{13}	1.14E+07 \pm 8.13E+06(+)	5.72E+06 \pm 3.53E+06(+)	4.60E+06 \pm 2.07E+06(+)	3.56E+06 \pm 2.87E+06(\approx)	3.43E+06 \pm 4.10E+06(\approx)
F_{14}	1.37E+07 \pm 1.65E+07(+)	9.32E+06 \pm 1.59E+06(\approx)	8.54E+06 \pm 1.44E+06(\approx)	8.65E+06 \pm 1.20E+06(\approx)	8.75E+06 \pm 1.38E+06(\approx)
F_{15}	3.79E+07 \pm 4.41E+07(+)	9.52E+06 \pm 2.41E+06(+)	7.25E+06 \pm 1.87E+06(+)	5.90E+06 \pm 1.35E+06(+)	4.12E+06 \pm 8.20E+05(-)
+	8	6	5	1	2
-	2	1	1	0	1
\approx	5	8	9	14	12

TABLE S.V
OPTIMIZATION RESULTS ON THE 1000-D IEEE CEC2013 TEST SUITE WITH DIFFERENT SETTINGS OF α AND β

	SSLPSO ($\alpha=0.1, \beta=0.6$)	$\alpha=0.1, \beta=1.0$	$\alpha=0.2, \beta=1.0$	$\alpha=0.3, \beta=1.0$	$\alpha=0.4, \beta=1.0$	$\alpha=0.5, \beta=1.0$	$\alpha=0.6, \beta=1.0$	$\alpha=0.7, \beta=1.0$	$\alpha=0.8, \beta=1.0$
	Mean \pm Std	Mean \pm Std	Mean \pm Std	Mean \pm Std	Mean \pm Std	Mean \pm Std	Mean \pm Std	Mean \pm Std	Mean \pm Std
F_1	0.00E+00 \pm 0.00E+00	1.22E-29 \pm 6.67E-29(s)	0.00E+00 \pm 0.00E+00(s)	0.00E+00 \pm 0.00E+00(s)	0.00E+00 \pm 0.00E+00(s)	0.00E+00 \pm 0.00E+00(s)	0.00E+00 \pm 0.00E+00(s)	5.06E-26 \pm 1.33E-26(s)	3.29E-25 \pm 6.37E-26(s)
F_2	7.46E-02 \pm 5.87E+01	6.47E-02 \pm 3.78E+01(s)	5.20E-02 \pm 2.20E+01(s)	5.12E-02 \pm 2.27E+01(s)	7.03E-03 \pm 3.48E+03(s)	9.68E-03 \pm 9.81E+01(s)	9.78E-03 \pm 1.00E+02(s)	9.87E-03 \pm 7.49E+01(s)	9.90E-03 \pm 6.97E+01(s)
F_3	2.16E+01 \pm 6.83E-03	2.16E+01 \pm 5.15E-03(s)	2.16E+01 \pm 4.67E-03(s)	2.16E+01 \pm 6.58E-03(s)	2.16E+01 \pm 5.77E-03(s)	2.16E+01 \pm 4.35E-03(s)	2.16E+01 \pm 5.36E-03(s)	2.16E+01 \pm 7.10E-03(s)	2.16E+01 \pm 5.62E-03(s)
F_4	2.54E+08 \pm 4.75E+07	3.07E+08 \pm 6.60E+07(s)	5.19E+08 \pm 3.75E+08(s)	1.43E+09 \pm 3.75E+08(s)	2.69E+09 \pm 2.49E+08(s)	3.39E+09 \pm 3.15E+08(s)	4.23E+09 \pm 2.71E+08(s)	5.13E+09 \pm 3.39E+08(s)	5.81E+09 \pm 5.51E+08(s)
F_5	4.81E+05 \pm 7.62E+04	1.58E+06 \pm 2.85E+06(s)	2.20E+06 \pm 2.85E+06(s)	3.32E+06 \pm 3.28E+06(s)	4.61E+06 \pm 3.17E+06(s)	6.07E+06 \pm 2.30E+06(s)	5.17E+06 \pm 3.04E+06(s)	5.59E+06 \pm 2.70E+06(s)	6.72E+06 \pm 1.66E+06(s)
F_6	1.06E+06 \pm 1.72E+03	1.06E+06 \pm 9.87E+02(s)	1.06E+06 \pm 1.17E+03(s)	1.06E+06 \pm 1.23E+03(s)	1.06E+06 \pm 7.92E+02(s)	1.06E+06 \pm 9.55E+02(s)	1.06E+06 \pm 9.84E+02(s)	1.06E+06 \pm 1.57E+03(s)	1.06E+06 \pm 8.54E+02(s)
F_7	3.01E+08 \pm 3.8E+05	8.85E+04 \pm 4.92E+04(s)	2.24E+04 \pm 2.65E+04(s)	7.11E+04 \pm 2.59E+04(s)	2.58E+05 \pm 9.82E+04(s)	9.42E+05 \pm 2.80E+04(s)	2.01E+06 \pm 6.17E+05(s)	3.44E+06 \pm 1.14E+06(s)	5.02E+06 \pm 1.34E+06(s)
F_8	1.27E+13 \pm 2.19E+12	1.35E+13 \pm 2.25E+12(s)	2.67E+13 \pm 6.75E+12(s)	3.75E+13 \pm 5.57E+12(s)	5.05E+13 \pm 8.94E+12(s)	5.81E+13 \pm 1.18E+13(s)	7.08E+13 \pm 1.07E+13(s)	9.12E+13 \pm 1.36E+13(s)	1.23E+14 \pm 1.39E+13(s)
F_9	3.63E+07 \pm 5.92E+06	3.37E+07 \pm 8.89E+06(s)	4.87E+07 \pm 9.00E+07(s)	6.72E+07 \pm 1.28E+08(s)	1.20E+08 \pm 1.90E+08(s)	1.50E+08 \pm 2.04E+08(s)	1.36E+08 \pm 1.99E+08(s)	1.03E+08 \pm 1.62E+08(s)	7.93E+07 \pm 1.23E+08(s)
F_{10}	9.40E+07 \pm 2.60E+05	9.41E+07 \pm 1.82E+05(s)	9.40E+07 \pm 2.67E+05(s)	9.40E+07 \pm 2.45E+05(s)	9.40E+07 \pm 2.65E+05(s)	9.40E+07 \pm 2.24E+05(s)	9.40E+07 \pm 3.92E+05(s)	9.41E+07 \pm 2.17E+05(s)	9.40E+07 \pm 2.91E+05(s)
F_{11}	4.29E+06 \pm 2.80E+06	5.51E+06 \pm 2.27E+06(s)	1.81E+07 \pm 6.59E+06(s)	5.19E+07 \pm 1.18E+07(s)	8.88E+07 \pm 2.10E+07(s)	1.55E+08 \pm 4.20E+07(s)	1.91E+08 \pm 6.59E+07(s)	3.84E+08 \pm 2.91E+08(s)	5.76E+08 \pm 5.77E+08(s)
F_{12}	8.94E+02 \pm 2.51E+01	9.09E+02 \pm 2.76E+01(s)	9.17E+02 \pm 1.81E+01(s)	9.85E+02 \pm 7.84E+00(s)	9.88E+02 \pm 7.42E+01(s)	1.00E+03 \pm 8.84E+00(s)	1.01E+03 \pm 1.52E+00(s)	1.02E+03 \pm 1.90E+00(s)	1.02E+03 \pm 6.68E+01(s)
F_{13}	3.49E+06 \pm 3.19E+06	4.17E+06 \pm 4.78E+06(s)	4.71E+06 \pm 7.01E+06(s)	8.87E+07 \pm 3.67E+07(s)	2.97E+08 \pm 7.09E+07(s)	9.18E+08 \pm 5.15E+08(s)	2.19E+09 \pm 1.08E+09(s)	3.96E+09 \pm 1.09E+09(s)	3.50E+09 \pm 6.73E+08(s)
F_{14}	8.47E+06 \pm 1.05E+06	8.30E+06 \pm 7.47E+05(s)	9.38E+06 \pm 7.43E+05(s)	1.48E+07 \pm 2.24E+06(s)	2.84E+07 \pm 6.36E+06(s)	1.27E+08 \pm 9.11E+07(s)	6.97E+08 \pm 4.32E+08(s)	1.63E+09 \pm 1.11E+09(s)	2.58E+09 \pm 1.12E+09(s)
F_{15}	4.70E+06 \pm 7.95E+05	2.39E+07 \pm 3.16E+07(s)	1.14E+08 \pm 1.52E+07(s)	1.18E+08 \pm 1.15E+07(s)	1.11E+08 \pm 7.79E+06(s)	1.10E+08 \pm 9.98E+06(s)	1.03E+08 \pm 9.97E+06(s)	1.07E+08 \pm 1.12E+07(s)	1.03E+08 \pm 9.18E+06(s)
+ (SSLPSO is significantly better)									
- (SSLPSO is significantly worse)									
\approx	5	2	3	3	3	10	11	11	11
FUN	$\alpha=0.9, \beta=1.0$	$\alpha=0.1, \beta=0.9$	$\alpha=0.2, \beta=0.9$	$\alpha=0.3, \beta=0.9$	$\alpha=0.4, \beta=0.9$	$\alpha=0.5, \beta=0.9$	$\alpha=0.6, \beta=0.9$	$\alpha=0.7, \beta=0.9$	$\alpha=0.8, \beta=0.9$
	Mean \pm Std	Mean \pm Std	Mean \pm Std	Mean \pm Std	Mean \pm Std	Mean \pm Std	Mean \pm Std	Mean \pm Std	Mean \pm Std
F_1	3.90E-24 \pm 5.33E-25(s)	0.00E+00 \pm 0.00E+00(s)	0.00E+00 \pm 0.00E+00(s)	0.00E+00 \pm 0.00E+00(s)	0.00E+00 \pm 0.00E+00(s)	0.00E+00 \pm 0.00E+00(s)	1.55E-26 \pm 4.50E-27(s)	1.61E-25 \pm 2.85E-26(s)	6.50E-25 \pm 1.15E-25(s)
F_2	9.95E+03 \pm 6.51E+01(s)	6.62E+02 \pm 3.68E+01(s)	5.16E+02 \pm 2.17E+01(s)	5.16E+02 \pm 2.91E+01(s)	6.33E+03 \pm 3.80E+03(s)	9.57E+03 \pm 2.11E+02(s)	9.78E+03 \pm 8.99E+01(s)	9.83E+03 \pm 7.85E+01(s)	9.88E+03 \pm 7.07E+01(s)
F_3	2.16E+01 \pm 6.88E-03(s)	2.16E+01 \pm 5.18E-03(s)	2.16E+01 \pm 5.94E-03(s)	2.16E+01 \pm 7.10E-03(s)	2.16E+01 \pm 7.00E-03(s)	2.16E+01 \pm 5.37E-03(s)	2.16E+01 \pm 8.72E-03(s)	2.16E+01 \pm 6.82E-03(s)	2.16E+01 \pm 6.51E-03(s)
F_4	6.39E+09 \pm 4.74E+08(s)	2.87E+08 \pm 5.84E+07(s)	4.71E+08 \pm 6.93E+07(s)	1.02E+09 \pm 3.21E+08(s)	2.41E+09 \pm 4.42E+08(s)	3.20E+09 \pm 2.91E+08(s)	3.38E+09 \pm 3.38E+08(s)	4.62E+09 \pm 4.40E+08(s)	5.33E+09 \pm 4.00E+08(s)
F_5	8.84E+06 \pm 2.61E+06(s)	1.64E+06 \pm 2.51E+06(s)	2.07E+06 \pm 3.12E+06(s)	4.42E+06 \pm 3.32E+06(s)	5.02E+06 \pm 3.99E+06(s)	5.17E+06 \pm 3.99E+06(s)	5.10E+06 \pm 2.47E+06(s)	6.05E+06 \pm 2.47E+06(s)	6.64E+06 \pm 2.80E+06(s)
F_6	1.06E+06 \pm 9.92E+02(s)	1.06E+06 \pm 1.06E-03(s)	1.06E+06 \pm 9.65E+02(s)	1.06E+06 \pm 1.30E-03(s)	1.06E+06 \pm 1.18E-03(s)	1.06E+06 \pm 1.49E-03(s)	1.06E+06 \pm 1.14E-03(s)	1.06E+06 \pm 8.40E+02(s)	1.06E+06 \pm 1.13E-03(s)
F_7	7.57E+06 \pm 2.32E+06(s)	1.08E+05 \pm 8.62E+04(s)	1.58E+04 \pm 7.40E+03(s)	5.84E+04 \pm 2.98E+04(s)	1.76E+05 \pm 5.43E+04(s)	6.88E+05 \pm 2.69E+05(s)	1.46E+06 \pm 4.67E+05(s)	2.36E+06 \pm 7.29E+05(s)	3.90E+06 \pm 1.25E+06(s)
F_8	1.38E+14 \pm 1.82E+13(s)	1.46E+13 \pm 3.72E+12(s)	2.42E+13 \pm 7.07E+12(s)	3.93E+13 \pm 8.30E+12(s)	4.60E+13 \pm 6.17E+12(s)	5.28E+13 \pm 8.34E+12(s)	6.58E+13 \pm 1.22E+13(s)	7.86E+13 \pm 1.27E+13(s)	1.08E+14 \pm 1.94E+13(s)
F_9	1.25E+08 \pm 1.30E+08(s)	3.33E+07 \pm 5.33E+06(s)	4.75E+07 \pm 8.67E+07(s)	8.18E+07 \pm 1.53E+08(s)	8.15E+07 \pm 1.42E+08(s)	1.24E+08 \pm 1.89E+08(s)	1.64E+08 \pm 2.70E+08(s)	1.60E+08 \pm 2.70E+08(s)	1.27E+08 \pm 1.85E+08(s)
F_{10}	9.39E+07 \pm 3.03E+08(s)	9.40E+07 \pm 9.71E+05(s)	9.41E+07 \pm 1.97E+05(s)	9.41E+07 \pm 2.13E+05(s)	9.40E+07 \pm 2.39E+05(s)	9.41E+07 \pm 2.39E+05(s)	9.40E+07 \pm 2.39E+05(s)	9.40E+07 \pm 2.39E+05(s)	9.40E+07 \pm 2.39E+05(s)
F_{11}	1.89E+09 \pm 2.67E+09(s)	4.55E+06 \pm 2.75E+06(s)	1.53E+07 \pm 6.78E+06(s)	4.96E+07 \pm 2.71E+07(s)	8.56E+07 \pm 2.21E+07(s)	1.36E+08 \pm 2.98E+07(s)	1.84E+08 \pm 4.49E+07(s)	3.62E+08 \pm 6.27E+08(s)	5.86E+08 \pm 7.35E+08(s)
F_{12}	1.03E+03 \pm 1.20E+00(s)	9.01E+02 \pm 2.64E+01(s)	9.17E+02 \pm 1.73E+01(s)	9.60E+02 \pm 1.97E+00(s)	9.84E+02 \pm 8.38E+01(s)	9.99E+02 \pm 6.18E+01(s)	1.01E+03 \pm 1.37E+00(s)	1.02E+03 \pm 6.51E+01(s)	1.02E+03 \pm 5.46E+01(s)
F_{13}	3.84E+09 \pm 5.62E+08(s)	3.31E+06 \pm 1.56E+06(s)	9.43E+06 \pm 6.54E+06(s)	9.53E+07 \pm 5.10E+07(s)	3.01E+08 \pm 1.29E+08(s)	6.67E+08 \pm 2.28E+08(s)	2.15E+09 \pm 1.18E+09(s)	2.76E+09 \pm 1.07E+09(s)	3.32E+09 \pm 7.45E+08(s)
F_{14}	4.22E+09 \pm 2.81E+09(s)	8.31E+06 \pm 1.14E+06(s)	9.42E+06 \pm 9.64E+05(s)	1.33E+07 \pm 1.00E+06(s)	2.28E+07 \pm 3.91E+06(s)	3.89E+07 \pm 1.09E+07(s)	3.37E+08 \pm 2.98E+08(s)	9.28E+08 \pm 5.24E+08(s)	1.68E+09 \pm 1.09E+09(s)
F_{15}	1.04E+08 \pm 7.00E+06(s)	1.03E+07 \pm 1.57E+07(s)	1.19E+08 \pm 1.56E+07(s)	1.18E+08 \pm 1.68E+07(s)	1.13E+08 \pm 9.48E+06(s)	1.09E+08 \pm 1.14E+07(s)	1.06E+08 \pm 1.05E+07(s)	1.05E+08 \pm 6.56E+06(s)	1.03E+08 \pm 7.71E+06(s)
+	12	4	8	8	9	10	11	11	11
-	0	3	3	3	3	1	0	0	0
\approx	3	3	3	3	3	5	4	4	4
FUN	$\alpha=0.1, \beta=0.8$	$\alpha=0.2, \beta=0.8$	$\alpha=0.3, \beta=0.8$	$\alpha=0.4, \beta=0.8$	$\alpha=0.5, \beta=0.8$	$\alpha=0.6, \beta=0.8$	$\alpha=0.7, \beta=0.8$	$\alpha=0.1, \beta=0.7$	$\alpha=0.2, \beta=0.7$
	Mean \pm Std	Mean \pm Std	Mean \pm Std	Mean \pm Std	Mean \pm Std	Mean \pm Std	Mean \pm Std	Mean \pm Std	Mean \pm Std
F_1	1.11E-26 \pm 6.10E-26(s)	0.00E+00 \pm 0.00E+00(s)	0.00E+00 \pm 0.00E+00(s)	0.00E+00 \pm 0.00E+00(s)	0.00E+00 \pm 0.00E+00(s)	0.00E+00 \pm 0.00E+00(s)	8.88E-28 \pm 8.94E-28(s)	6.59E-26 \pm 1.25E-26(s)	0.00E+00 \pm 0.00E+00(s)
F_2	6.86E+02 \pm 3.88E+01(s)	5.15E+02 \pm 2.65E+01(s)	5.12E+02 \pm 2.63E+01(s)	4.94E+03 \pm 3.81E+03(s)	9.47E+03 \pm 5.18E+02(s)	9.71E+03 \pm 1.01E+02(s)	9.78E+03 \pm 7.27E+01(s)	7.24E+02 \pm 5.61E+01(s)	9.88E+03 \pm 7.07E+01(s)
F_3									

TABLE S.VI
OPTIMIZATION RESULTS OF THE ABLATION EXPERIMENTS OF THE RIS AND RIL STRATEGIES ON THE 1000-D IEEE CEC2013 TEST SUITE

FUN	SSLPSO	SSLPSO-w/o-RIL	SSLPSO-w/o-RIS
	Mean \pm Std	Mean \pm Std	Mean \pm Std
F_1	0.00E+00 \pm 0.00E+00	1.17E-23 \pm 1.35E-24(+)	3.07E-22 \pm 5.55E-23(+)
F_2	7.46E+02 \pm 5.77E+01	9.93E+03 \pm 8.48E+01(+)	9.53E+02 \pm 5.81E+01(+)
F_3	2.16E+01 \pm 6.72E-03	2.16E+01 \pm 5.40E-03(\approx)	2.01E+01 \pm 7.03E-02(-)
F_4	2.54E+08 \pm 4.67E+07	7.46E+09 \pm 1.24E+09(+)	4.23E+08 \pm 1.25E+08(+)
F_5	4.81E+05 \pm 7.62E+04	6.32E+06 \pm 2.26E+06(+)	5.45E+05 \pm 1.14E+05(\approx)
F_6	1.06E+06 \pm 1.25E+03	1.06E+06 \pm 1.07E+03(\approx)	9.99E+05 \pm 1.32E+03(-)
F_7	3.01E+05 \pm 3.77E+05	8.78E+06 \pm 2.26E+06(+)	5.56E+05 \pm 2.91E+05(+)
F_8	1.27E+13 \pm 2.15E+12	1.41E+14 \pm 1.67E+13(+)	1.68E+13 \pm 5.39E+12(+)
F_9	3.63E+07 \pm 5.82E+06	1.09E+08 \pm 1.56E+08(+)	3.74E+07 \pm 6.21E+06(\approx)
F_{10}	9.40E+07 \pm 2.61E+05	9.40E+07 \pm 2.49E+05(\approx)	9.06E+07 \pm 4.31E+04(-)
F_{11}	4.29E+06 \pm 2.75E+06	4.36E+09 \pm 5.07E+09(+)	6.22E+06 \pm 2.79E+06(+)
F_{12}	8.94E+02 \pm 2.47E+01	1.03E+03 \pm 1.18E+00(+)	1.06E+03 \pm 5.23E+02(+)
F_{13}	3.49E+06 \pm 3.14E+06	3.84E+09 \pm 4.94E+08(+)	5.55E+06 \pm 2.67E+06(+)
F_{14}	8.47E+06 \pm 1.04E+06	5.68E+09 \pm 3.47E+09(+)	1.42E+07 \pm 3.73E+06(+)
F_{15}	4.70E+06 \pm 7.81E+05	1.02E+08 \pm 9.19E+06(+)	4.75E+06 \pm 4.46E+05(\approx)
+(SSLPSO is significantly better)		12	9
-(SSLPSO is significantly worse)		0	3
\approx		3	3

TABLE S.VII
OPTIMIZATION RESULTS ON THE 1000-D IEEE CEC2013 TEST SUITE WITH DIFFERENT UPDATE CHOICES

FUN	SSLPSO (ASA)	SSLPSO (One)	SSLPSO (Two)
	Mean \pm Std	Mean \pm Std	Mean \pm Std
F_1	0.00E+00 \pm 0.00E+00	5.39E-29 \pm 1.96E-28(\approx)	9.34E-02 \pm 2.60E-01(+)
F_2	7.46E+02 \pm 5.87E+01	6.94E+02 \pm 3.59E+01(-)	1.26E+04 \pm 2.99E+02(+)
F_3	2.16E+01 \pm 6.83E-03	2.16E+01 \pm 7.12E-03(\approx)	2.16E+01 \pm 5.61E-03(\approx)
F_4	2.54E+08 \pm 4.75E+07	2.61E+08 \pm 5.99E+07(\approx)	3.61E+09 \pm 5.32E+08(+)
F_5	4.81E+05 \pm 7.62E+04	1.35E+06 \pm 2.21E+06(\approx)	5.91E+05 \pm 7.34E+04(+)
F_6	1.06E+06 \pm 1.27E+03	1.06E+06 \pm 7.08E+02(+)	1.06E+06 \pm 8.41E+02(\approx)
F_7	3.01E+05 \pm 3.84E+05	2.08E+05 \pm 8.41E+04(\approx)	1.09E+06 \pm 2.31E+05(+)
F_8	1.27E+13 \pm 2.19E+12	1.30E+13 \pm 2.36E+12(\approx)	7.34E+13 \pm 1.81E+13(+)
F_9	3.63E+07 \pm 5.92E+06	3.51E+07 \pm 5.75E+06(\approx)	3.38E+07 \pm 7.31E+06(\approx)
F_{10}	9.40E+07 \pm 2.66E+05	9.40E+07 \pm 2.08E+05(\approx)	9.40E+07 \pm 1.80E+05(\approx)
F_{11}	4.29E+06 \pm 2.80E+06	4.22E+06 \pm 2.19E+06(\approx)	8.03E+09 \pm 1.36E+10(+)
F_{12}	8.94E+02 \pm 2.51E+01	9.07E+02 \pm 1.94E+01(+)	5.64E+10 \pm 1.42E+10(+)
F_{13}	3.49E+06 \pm 3.19E+06	3.07E+06 \pm 1.63E+06(\approx)	2.85E+10 \pm 3.69E+10(+)
F_{14}	8.47E+06 \pm 1.05E+06	8.75E+06 \pm 1.72E+06(\approx)	1.94E+09 \pm 3.15E+09(+)
F_{15}	4.70E+06 \pm 7.95E+05	5.51E+06 \pm 1.20E+06(+)	1.80E+08 \pm 2.31E+07(+)
+(SSLPSO(ASA) is significantly better)		3	11
-(SSLPSO(ASA) is significantly worse)		1	0
\approx		11	4

TABLE S.VIII
RESULTS FOR THE WDN BENCHMARK SUITE

FUN	SSLSPO	TSOL	LLSORL	RCI-PSO	HCLPSO
	Mean±Std	Mean±Std	Mean±Std	Mean±Std	Mean±Std
S200	6.54E+06 ± 2.20E+05	6.83E+06 ± 3.07E+05 (+)	7.11E+06 ± 4.05E+05 (+)	6.76E+06 ± 1.58E+05 (+)	7.02E+06 ± 2.74E+05 (+)
S300	2.42E+07 ± 5.50E+05	2.55E+07 ± 1.04E+06 (+)	2.55E+07 ± 9.58E+05 (+)	2.49E+07 ± 7.48E+05 (+)	2.55E+07 ± 5.53E+05 (+)
S400	3.87E+07 ± 5.97E+05	4.13E+07 ± 1.72E+06 (+)	3.95E+07 ± 8.35E+05 (+)	3.91E+07 ± 6.25E+05 (+)	4.10E+07 ± 5.78E+05 (+)
S500	1.33E+08 ± 6.02E+06	8.01E+08 ± 1.34E+09 (+)	1.41E+08 ± 5.57E+06 (+)	1.42E+08 ± 9.12E+06 (+)	1.43E+08 ± 6.07E+06 (+)
S600	1.67E+08 ± 5.14E+06	2.38E+09 ± 4.53E+09 (+)	4.02E+08 ± 1.14E+09 (+)	2.13E+08 ± 2.08E+08 (+)	3.27E+08 ± 4.60E+08 (+)
B200	3.94E+06 ± 1.02E+05	4.07E+06 ± 9.28E+04 (+)	4.21E+06 ± 1.20E+05 (+)	4.19E+06 ± 8.22E+04 (+)	4.34E+06 ± 1.17E+05 (+)
B300	1.33E+07 ± 3.66E+05	1.41E+07 ± 6.53E+05 (+)	1.36E+07 ± 4.08E+05 (+)	1.37E+07 ± 2.59E+05 (+)	1.42E+07 ± 3.62E+05 (+)
B400	2.16E+07 ± 5.02E+05	2.32E+07 ± 8.93E+05 (+)	2.22E+07 ± 5.18E+05 (+)	2.19E+07 ± 3.97E+05 (+)	2.32E+07 ± 5.40E+05 (+)
B500	8.08E+07 ± 3.01E+06	8.42E+07 ± 3.72E+06 (+)	8.26E+07 ± 2.72E+06 (+)	8.01E+07 ± 4.06E+06 (≈)	8.44E+07 ± 3.45E+06 (+)
B600	6.67E+07 ± 8.65E+05	7.12E+07 ± 3.24E+06 (+)	7.19E+07 ± 1.00E+06 (+)	6.78E+07 ± 1.35E+06 (+)	7.26E+07 ± 1.23E+06 (+)
I200	3.93E+06 ± 6.82E+04	4.16E+06 ± 1.73E+05 (+)	4.14E+06 ± 1.48E+05 (+)	4.17E+06 ± 5.90E+04 (+)	4.29E+06 ± 8.74E+04 (+)
I300	1.32E+07 ± 3.74E+05	1.42E+07 ± 7.36E+05 (+)	1.36E+07 ± 4.85E+05 (+)	1.36E+07 ± 2.77E+05 (+)	1.42E+07 ± 3.43E+05 (+)
I400	2.61E+07 ± 1.67E+06	2.78E+07 ± 2.16E+06 (+)	2.67E+07 ± 1.67E+06 (+)	2.62E+07 ± 1.36E+06 (≈)	2.78E+07 ± 1.66E+06 (+)
I500	7.92E+07 ± 3.48E+06	8.31E+07 ± 5.84E+06 (+)	8.26E+07 ± 4.01E+06 (+)	8.10E+07 ± 3.46E+06 (+)	8.58E+07 ± 4.60E+06 (+)
I600	1.18E+08 ± 8.17E+06	1.23E+08 ± 6.71E+06 (+)	1.24E+08 ± 6.15E+06 (+)	1.17E+08 ± 8.39E+06 (≈)	1.23E+08 ± 6.24E+06 (+)
+(SSLSPO is significantly better)		15	15	12	15
-(SSLSPO is significantly worse)		0	0	0	0
≈		0	0	3	0

TABLE S.IX
OPTIMIZATION RESULTS ON THE 2000-D IEEE CEC2010 TEST SUITE

FUN	SSLSPO	RCI-PSO	HCLPSO	SDLSO	AGLDPSO	SLPSO-ARS	μDSDE
	Mean±Std	Mean±Std	Mean±Std	Mean±Std	Mean±Std	Mean±Std	Mean±Std
f ₁	2.19E-23 ± 7.87E-24	9.05E-21 ± 6.87E-22 (+)	1.24E-18 ± 2.27E-19 (+)	1.72E-16 ± 2.17E-17 (+)	3.38E-20 ± 1.80E-21 (+)	1.47E-17 ± 8.28E-19 (+)	4.06E+11 ± 3.85E+10 (+)
f ₂	1.22E+03 ± 4.03E+01	1.83E+03 ± 4.89E+01 (+)	1.52E+03 ± 5.23E+01 (+)	1.05E+03 ± 3.45E+01 (-)	6.13E+03 ± 3.02E+02 (+)	6.92E+03 ± 1.12E+03 (+)	2.49E+04 ± 5.11E+02 (+)
f ₃	7.90E-14 ± 2.95E-15	5.79E-14 ± 3.49E-15 (-)	1.56E-12 ± 1.75E-13 (+)	2.84E-11 ± 1.46E-12 (+)	4.41E+00 ± 3.72E-01 (+)	1.57E-12 ± 1.47E-14 (+)	2.16E+01 ± 3.20E-02 (+)
f ₄	1.15E+11 ± 1.72E+10	1.55E+11 ± 1.91E+10 (+)	1.08E+12 ± 1.77E+11 (+)	5.95E+11 ± 6.83E+10 (+)	3.06E+11 ± 7.24E+10 (+)	1.06E+12 ± 1.49E+11 (+)	4.26E+15 ± 1.03E+15 (+)
f ₅	6.97E+08 ± 9.35E+06	1.86E+07 ± 3.25E+06 (-)	1.39E+07 ± 2.83E+06 (-)	9.72E+06 ± 2.35E+06 (-)	1.44E+08 ± 2.19E+08 (-)	1.55E+07 ± 3.07E+06 (-)	1.12E+09 ± 1.09E+08 (+)
f ₆	7.76E-09 ± 1.04E-10	7.99E-09 ± 3.02E-14 (+)	2.66E-08 ± 2.66E-09 (+)	2.42E-08 ± 2.36E-09 (+)	3.98E+01 ± 2.27E-02 (+)	6.71E-07 ± 2.38E-08 (+)	2.14E+07 ± 1.38E+05 (+)
f ₇	1.14E-05 ± 3.62E-05	1.42E+03 ± 4.89E+03 (+)	1.31E+04 ± 4.76E+03 (+)	8.76E+04 ± 1.22E+04 (+)	2.20E+06 ± 4.27E+05 (+)	4.03E+05 ± 7.39E+04 (+)	4.03E+11 ± 1.45E+11 (+)
f ₈	3.75E+03 ± 1.88E+03	1.92E+04 ± 4.15E+03 (+)	7.21E+07 ± 1.49E+05 (+)	5.53E+07 ± 2.33E+05 (+)	3.75E+05 ± 9.91E+05 (+)	6.50E+07 ± 1.72E+05 (+)	1.47E+17 ± 3.93E+16 (+)
f ₉	1.70E+07 ± 1.58E+06	2.39E+07 ± 8.82E+05 (+)	1.21E+08 ± 6.93E+06 (+)	8.76E+07 ± 4.21E+06 (+)	6.23E+07 ± 4.62E+06 (+)	1.77E+08 ± 9.50E+06 (+)	4.11E+11 ± 2.85E+10 (+)
f ₁₀	1.49E+03 ± 5.97E+01	1.83E+03 ± 4.85E+01 (+)	1.54E+03 ± 4.84E+01 (+)	1.72E+04 ± 4.80E+02 (+)	6.59E+03 ± 3.65E+02 (+)	6.67E+03 ± 9.26E+02 (+)	2.51E+04 ± 4.72E+02 (+)
f ₁₁	2.76E-13 ± 5.83E-15	4.71E-13 ± 1.62E-14 (+)	4.13E-11 ± 7.74E-12 (+)	3.92E-10 ± 3.80E-11 (+)	5.77E+01 ± 1.30E+01 (+)	1.48E-11 ± 3.48E-13 (+)	2.37E+02 ± 2.70E-01 (+)
f ₁₂	2.09E+03 ± 2.81E+02	2.43E+03 ± 1.89E+02 (-)	1.60E+05 ± 5.77E+03 (+)	2.94E+05 ± 1.36E+04 (+)	1.15E+04 ± 1.05E+03 (+)	2.55E+05 ± 8.36E+03 (+)	3.96E+07 ± 9.98E+06 (+)
f ₁₃	4.42E+02 ± 8.76E+01	7.65E+02 ± 8.88E+01 (+)	1.19E+03 ± 1.80E+02 (+)	1.05E+03 ± 1.28E+02 (+)	1.39E+03 ± 1.90E+02 (+)	1.25E+03 ± 3.49E+02 (+)	4.26E+12 ± 3.40E+11 (+)
f ₁₄	5.52E+07 ± 2.27E+06	7.09E+07 ± 2.41E+06 (+)	3.62E+08 ± 1.83E+07 (+)	2.97E+08 ± 9.94E+06 (+)	1.72E+08 ± 8.88E+06 (+)	9.22E+08 ± 4.00E+07 (+)	4.82E+11 ± 4.43E+10 (+)
f ₁₅	2.12E+04 ± 2.04E+02	1.83E+04 ± 1.04E+02 (-)	1.69E+03 ± 6.14E+01 (-)	2.16E+04 ± 4.67E+02 (+)	7.13E+03 ± 3.05E+02 (-)	6.54E+03 ± 9.45E+02 (-)	2.52E+04 ± 4.87E+02 (+)
f ₁₆	4.75E-13 ± 4.41E-15	9.48E-02 ± 3.55E-01 (+)	1.03E+00 ± 1.31E+00 (+)	3.42E-02 ± 1.84E-01 (+)	1.93E+02 ± 3.69E+01 (+)	2.51E-11 ± 5.10E-13 (+)	4.31E+02 ± 3.97E-01 (+)
f ₁₇	7.47E+04 ± 1.17E+04	5.31E+04 ± 2.35E+03 (-)	8.80E+05 ± 3.06E+04 (+)	2.16E+06 ± 1.13E+05 (+)	1.17E+05 ± 6.88E+03 (+)	1.04E+06 ± 3.77E+04 (+)	9.24E+07 ± 2.53E+07 (+)
f ₁₈	1.42E+03 ± 1.73E+02	4.11E+03 ± 2.43E+02 (+)	4.16E+03 ± 2.63E+02 (+)	2.74E+03 ± 5.40E+02 (+)	3.81E+03 ± 4.92E+02 (+)	3.38E+03 ± 1.02E+03 (+)	8.69E+12 ± 5.44E+11 (+)
f ₁₉	5.19E+07 ± 2.61E+06	4.25E+06 ± 1.56E+05 (-)	1.21E+07 ± 6.89E+05 (-)	1.42E+08 ± 1.37E+08 (+)	3.27E+06 ± 1.33E+05 (-)	5.66E+06 ± 3.85E+05 (-)	1.32E+08 ± 3.26E+07 (+)
f ₂₀	1.79E+03 ± 5.02E+01	2.00E+03 ± 8.04E+01 (+)	2.94E+03 ± 2.48E+02 (+)	2.06E+03 ± 9.34E+01 (+)	3.49E+03 ± 2.15E+02 (+)	2.04E+03 ± 1.77E+02 (+)	8.98E+12 ± 4.22E+11 (+)
+(SSLSPO is significantly better)		14	17	18	17	17	20
-(SSLSPO is significantly worse)		6	3	2	3	3	0
≈		0	0	0	0	0	0
FUN	SSLSPO	TPLSO	DLLSO	SPLSO	CCPSO2	DDG	EADG
	Mean±Std	Mean±Std	Mean±Std	Mean±Std	Mean±Std	Mean±Std	Mean±Std
f ₁	2.19E-23 ± 7.87E-24	3.16E-17 ± 9.82E-18 (+)	1.66E-20 ± 7.10E-22 (+)	5.42E-08 ± 1.27E-08 (+)	3.54E+04 ± 2.71E+03 (+)	4.26E+07 ± 3.38E+07 (+)	5.77E+07 ± 6.54E+07 (+)
f ₂	1.22E+03 ± 4.03E+01	2.30E+03 ± 2.08E+02 (+)	1.40E+03 ± 4.29E+01 (+)	1.01E+04 ± 1.39E+03 (+)	5.10E-02 ± 1.43E-02 (-)	1.26E+04 ± 5.50E+02 (+)	1.28E+04 ± 7.40E+02 (+)
f ₃	7.90E-14 ± 2.95E-15	3.20E+00 ± 2.62E-01 (+)	5.83E-14 ± 1.32E-15 (-)	3.94E-07 ± 5.82E-08 (+)	2.94E+01 ± 1.24E+01 (+)	2.68E+01 ± 6.39E-01 (+)	2.10E+01 ± 1.52E+00 (+)
f ₄	1.15E+11 ± 1.72E+10	8.06E+11 ± 1.79E+11 (+)	1.42E+12 ± 2.55E+11 (+)	1.40E+12 ± 1.77E+11 (+)	1.96E+13 ± 1.20E+13 (+)	1.56E+12 ± 3.45E+11 (+)	4.80E+10 ± 2.99E+10 (-)
f ₅	6.97E+08 ± 9.35E+06	5.00E+07 ± 1.17E+08 (-)	1.44E+07 ± 3.56E+06 (-)	6.96E+08 ± 1.35E+07 (≈)	1.05E+09 ± 1.68E+08 (+)	1.82E+08 ± 3.05E+07 (-)	1.32E+08 ± 1.64E+07 (-)
f ₆	7.76E-09 ± 9.01E-10	3.52E+00 ± 9.77E-01 (+)	8.30E-09 ± 7.95E-11 (+)	1.62E-06 ± 1.74E-07 (+)	3.91E+07 ± 2.56E+06 (+)	2.38E+06 ± 1.09E+06 (+)	5.86E+04 ± 2.19E+05 (+)
f ₇	1.14E-05 ± 3.62E-05	1.48E+05 ± 6.95E+04 (+)	8.51E+04 ± 2.34E+04 (+)	8.01E+05 ± 1.08E+05 (+)	7.75E+09 ± 7.88E+09 (+)	5.62E+06 ± 6.18E+05 (+)	2.01E+05 ± 3.58E+04 (+)
f ₈	3.75E+03 ± 1.88E+03	5.31E+07 ± 1.35E+07 (+)	6.99E+07 ± 1.20E+05 (+)	7.97E+07 ± 9.26E+04 (+)	4.82E+08 ± 4.92E+08 (+)	1.63E+08 ± 5.36E+07 (+)	3.00E+06 ± 2.35E+06 (+)
f ₉	1.70E+07 ± 1.58E+06	1.07E+08 ± 7.92E+06 (+)	1.03E+08 ± 4.85E+06 (+)	2.09E+08 ± 1.21E+07 (+)	6.46E+08 ± 2.65E+08 (+)	5.28E+08 ± 1.48E+08 (+)	3.62E+08 ± 9.57E+07 (+)
f ₁₀	1.49E+03 ± 5.97E+01	1.17E+04 ± 7.56E+03 (+)	1.17E+03 ± 2.44E+01 (-)	2.00E+04 ± 1.81E+02 (+)	1.13E+04 ± 1.70E+03 (+)	1.95E+04 ± 2.62E+03 (+)	7.93E+03 ± 2.81E+02 (+)
f ₁₁	2.76E-13 ± 5.83E-15	6.56E+00 ± 1.97E+00 (+)	5.60E-13 ± 1.97E-14 (+)	5.22E-06 ± 5.16E-07 (+)	4.35E+02 ± 9.67E+00 (+)	4.12E+02 ± 1.14E+01 (+)	2.31E+01 ± 2.04E+00 (+)
f ₁₂	2.09E+03 ± 2.81E+02	7.63E+04 ± 4.73E+03 (+)	1.03E+05 ± 4.82E+03 (+)	1.15E+06 ± 1.60E+05 (+)	5.45E+05 ± 2.21E+05 (+)	3.44E+05 ± 3.36E+04 (+)	1.91E+05 ± 2.66E+04 (+)
f ₁₃	4.42E+02 ± 8.76E+01	1.84E+03 ± 2.93E+02 (+)	1.21E+03 ± 2.05E+02 (+)	1.21E+03 ± 3.43E+02 (+)	1.24E+04 ± 6.20E+03 (+)	1.74E+07 ± 3.66E+07 (+)	1.85E+05 ± 3.12E+04 (+)
f ₁₄	5.52E+07 ± 2.27E+06	2.98E+08 ± 1.46E+07 (+)	2.82E+08 ± 1.14E+07 (+)	7.56E+08 ± 3.02E+07 (+)	1.74E+09 ± 8.40E+08 (+)	1.18E+09 ± 7.46E+07 (+)	4.36E+07 ± 2.61E+06 (-)
f ₁₅	2.12E+04 ± 1.04E+02	2.11E+04 ± 7.93E+01 (-)	2.06E+04 ± 7.47E+01 (-)	2.10E+04 ± 8.30E+01 (-)	2.38E+04 ± 1.72E+03 (+)	1.80E+04 ± 3.40E+03 (≈)	6.53E+03 ± 2.01E+02 (-)
f ₁₆	4.75E-13 ± 4.41E-15	4.27E+01 ± 1.10E+01 (+)	1.00E+00 ± 1.14E+00 (+)	9.08E-06 ± 9.92E-07 (+)	8.01E+02 ± 6.36E+00 (+)	8.20E+02 ± 2.15E+00 (+)	2.20E-01 ± 5.10E-01 (+)
f ₁₇	7.47E+04 ± 1.17E+04	4.07E+05 ± 1.89E+04 (+)	5.89E+05 ± 1.75E+04 (+)	3.12E+06 ± 1.60E+05 (+)	1.31E+06 ± 5.34E+05 (+)	8.03E+05 ± 6.12E+04 (+)	3.24E+01 ± 3.66E+01 (-)
f ₁₈	1.42E+03 ± 1.73E+02	6.19E+03 ± 1.15E+03 (+)	4.47E+03 ± 1.12E+03 (+)	5.09E+03 ± 3.02E+03 (+)	4.43E+04 ± 4.45E+04 (+)	5.24E+09 ± 5.64E+09 (+)	1.97E+03 ± 1.92E+02 (+)
f ₁₉	5.19E+07 ± 2.61E+06	1.08E+07 ± 5.36E+05 (-)	2.55E+07 ± 1.31E+06 (-)	4.18E+07 ± 2.06E+06 (-)	8.96E+06 ± 1.40E+06 (-)	2.96E+06 ± 1.80E+05 (-)	1.94E+06 ± 1.05E+05 (-)
f ₂₀	1.79E+03 ± 5.02E+01	4.43E+03 ± 2.56E+02 (+)	2.86E+03 ± 3.64E+02 (+)	2.22E+03 ± 3.51E+02 (+)	2.56E+04 ± 2.71E+04 (+)	5.46E+09 ± 4.35E+09 (+)	1.30E+08 ± 1.68E+08 (+)
+		17	15	17	18	17	14
-		3	5	2	2	2	6
≈		0	0	1	0	1	0

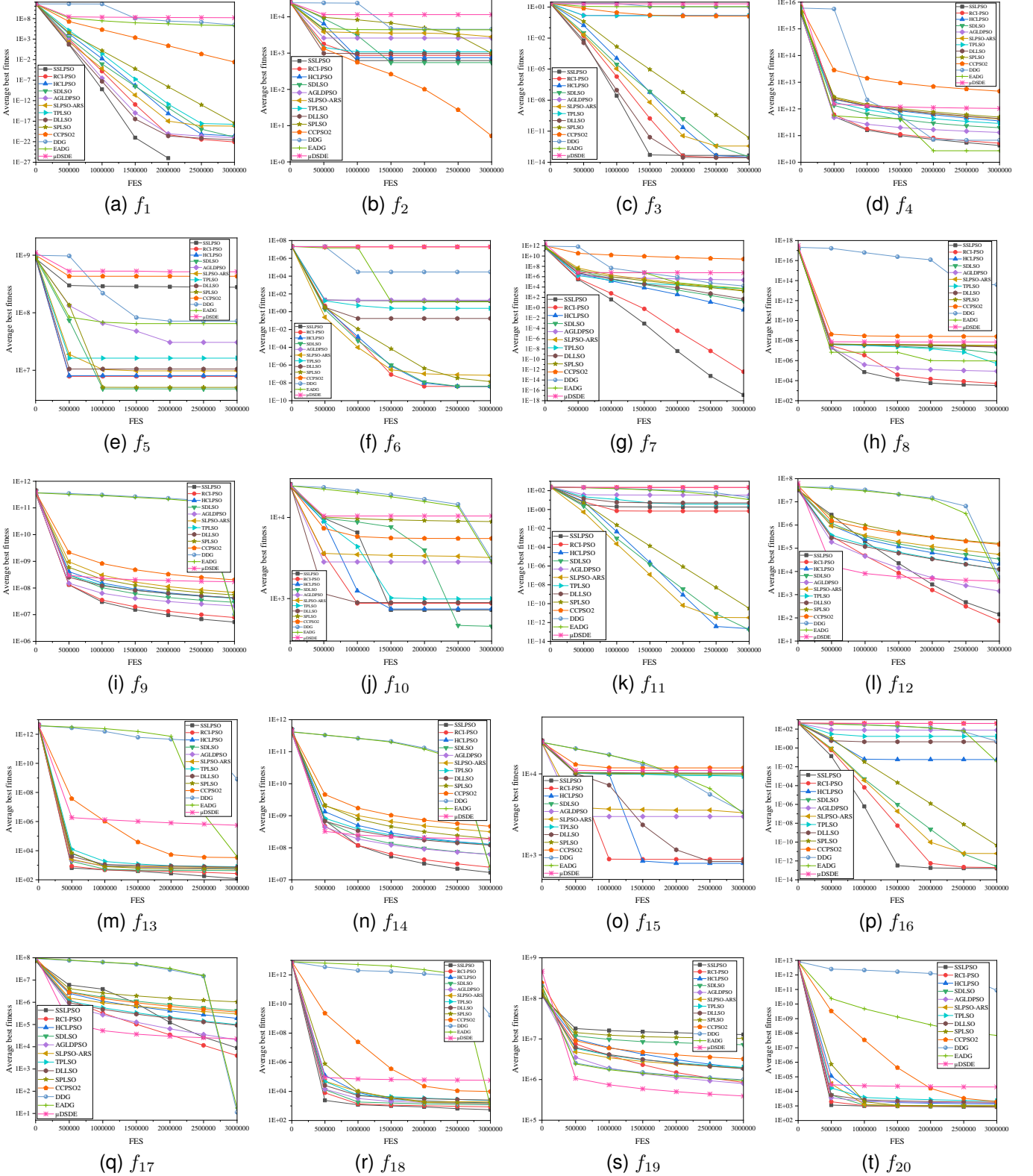


Fig. S.1. Comparison of the convergence behavior of BLPSO with other comparison algorithms on the 1000-dimensional CEC2010 benchmark functions.

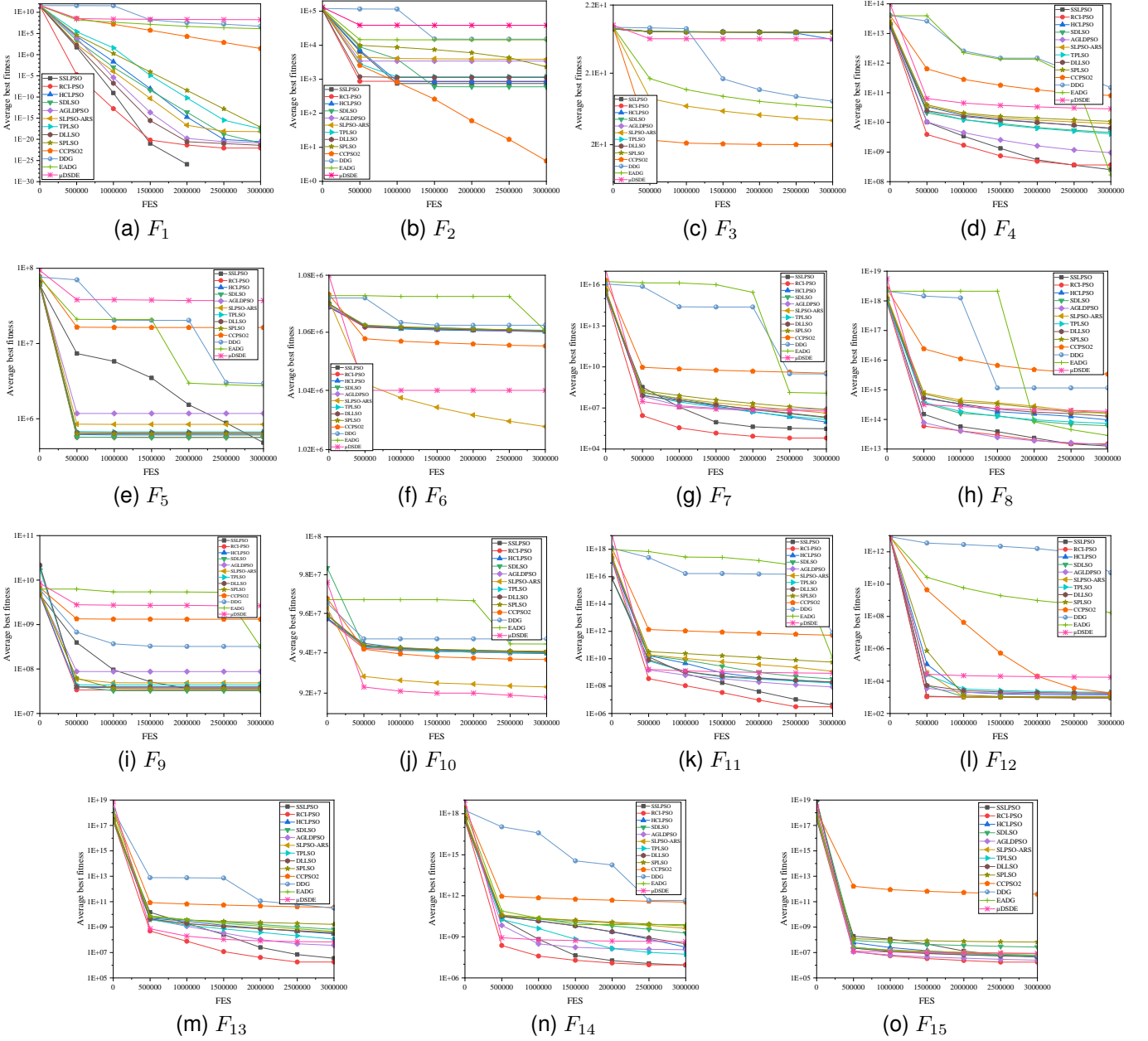


Fig. S.2. Comparison of the convergence behavior of BLPSO with other comparison algorithms on the 1000-dimensional CEC2013 benchmark functions.