

Comparative Study of Modern Differential Evolution Algorithms: Perspectives on Mechanisms and Performance

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Abstract: Since the discovery of the Differential Evolution algorithm, new and improved versions have continuously emerged. In this paper, we review selected algorithms based on Differential Evolution proposed in recent years. We examine the mechanisms integrated into them and compare the performances of algorithms. To compare their performances statistical comparisons were used as they enable us to draw reliable conclusions about algorithms performances. We use the Wilcoxon signed-rank test for pairwise comparisons and the Friedman test for multiple comparisons. Subsequently, the Mann-Whitney U-score test was added. We conducted not only a cumulative analysis of algorithms but we also focused on their performances regarding the function family (i.e., unimodal, multimodal, hybrid, and composition functions). Experimental results of algorithms were obtained on problems defined for the CEC'24 Special Session and Competition on Single Objective Real Parameter Numerical Optimization. Problem dimensions of 10, 30, 50, and 100 were analyzed. In this paper we highlight promising mechanisms for further development and improvements, based on the performed study of the selected algorithms.

Keywords: global optimization; differential evolution; benchmark suite; mechanisms; statistical tests; performance

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Supplementary Material

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Table S1. Results of DE for 10D.

Func.	Best	Worst	Median	Mean	Std
f1	0	0	0	0	0
f2	0	0	0	0	0
f3	0	2.5659e-02	0	1.0264e-03	5.1318e-03
f4	15.1610	29.5728	24.3916	23.5513	3.3777
f5	0	0	0	0	0
f6	23.2805	39.5093	33.5636	33.7499	3.6944
f7	17.5996	28.8498	23.7981	23.3779	3.3567
f8	0	0	0	0	0
f9	610.2874	1229.7924	976.7530	972.2365	177.2143
f10	0	0.9950	8.0000e-08	3.9883e-02	0.1990
f11	9.0000e-08	1.9513	0.2081	0.3423	0.3748
f12	1.1900e-06	10.7759	2.9792	3.5732	2.9019
f13	0	4.2496	0	0.2138	0.8639
f14	1.0007e-04	2.2584e-02	1.3445e-03	2.9625e-03	4.6535e-03
f15	1.9750e-02	0.6558	0.2705	0.3015	0.1617
f16	2.6562e-03	19.8576	3.1720	5.7228	6.0687
f17	1.5370e-05	0.2315	1.8141e-03	1.3213e-02	4.5822e-02
f18	0	3.5779e-02	2.4000e-07	6.2545e-03	1.1890e-02
f19	0	0.6243	0.3122	0.2123	0.1738
f20	100.0000	231.7728	219.4704	169.4712	62.9333
f21	0	100.9284	100.0000	96.1594	20.0346
f22	300.0000	320.3463	311.5139	310.6149	5.9574
f23	100.0000	353.9653	345.6333	256.4229	120.2072
f24	397.7429	445.7953	398.0090	399.8407	9.5747
f25	300.0000	300.0000	300.0000	300.0000	0
f26	388.8605	393.8188	389.5180	390.0890	1.6754
f27	300.0000	300.0000	300.0000	300.0000	0
f28	230.5995	248.8666	240.4265	240.1197	4.3986
f29	394.5464	407.7369	394.8307	396.8685	4.8002

Table S2. Results of DE for 30D.

Func.	Best	Worst	Median	Mean	Std
f1	0	0	0	0	0
f2	0.4863	34.8465	9.5596	12.1225	9.0058
f3	58.5616	64.1174	58.5616	58.7838	1.1112
f4	152.8653	192.9418	180.9231	179.1810	8.5977
f5	0	2.0000e-08	0	0	0
f6	185.4512	225.7137	209.7045	209.6285	9.8081
f7	157.1892	192.4045	183.2427	181.2514	7.9663
f8	0	0	0	0	0
f9	6387.9141	7117.8308	6886.7925	6825.4268	211.4563
f10	5.0718	64.1106	54.3105	50.1288	14.6796
f11	2310.5448	1.6761e+04	5597.1030	7149.2135	4524.5264
f12	56.4323	93.4511	80.8441	79.8439	9.0122
f13	52.7319	70.8641	63.7063	63.6367	4.3095
f14	9.9173	50.4888	37.1063	35.0112	9.1651
f15	17.4421	1413.0677	906.5769	735.2669	445.3031
f16	55.4180	88.3237	72.0570	71.1435	7.2400
f17	23.6417	40.8406	36.3871	36.0905	4.1997
f18	6.8443	26.2776	14.9525	17.0103	6.3938
f19	0.6450	49.8829	24.9168	25.2129	15.3827
f20	351.7291	380.5569	367.9183	368.5389	7.5346
f21	100.0000	100.0000	100.0000	100.0000	0
f22	500.2176	535.8518	519.2163	519.9889	10.5863
f23	566.1475	601.9977	583.6584	584.8942	10.2894
f24	386.6951	386.7743	386.7405	386.7411	2.1635e-02
f25	300.0000	2721.6894	2414.2718	2258.4716	608.9886
f26	471.4605	505.8326	491.1981	490.6236	8.3162
f27	300.0000	403.2857	300.0000	312.3943	34.2560
f28	407.5301	907.7349	499.3454	540.3465	121.3232
f29	1950.0505	2136.0908	1979.1562	1987.7943	38.5875

Table S3. Results of DE for 50D.

Func.	Best	Worst	Median	Mean	Std
f1	2.4572e-02	1171.8254	6.9533	77.1775	238.7580
f2	3.6342e+04	8.4420e+04	5.5061e+04	5.6631e+04	1.2583e+04
f3	28.5127	152.3715	97.4131	81.1508	44.8551
f4	324.8539	377.1001	353.7323	354.1972	12.1989
f5	0	1.2580e-05	0	1.0560e-06	3.4705e-06
f6	376.3920	424.9998	402.8901	402.8993	13.2481
f7	320.2857	373.5660	360.2344	356.6496	11.9238
f8	0	8.9528e-02	0	1.4325e-02	3.3498e-02
f9	1.2146e+04	1.3490e+04	1.3005e+04	1.2895e+04	315.9155
f10	34.1274	154.6287	144.3631	130.6679	36.9136
f11	1.7956e+04	1.7290e+05	5.4550e+04	6.3963e+04	4.8924e+04
f12	186.1449	630.8430	265.5598	281.1683	89.6075
f13	105.3826	143.9113	126.4291	125.2950	9.1703
f14	93.8350	129.9411	107.9778	109.6400	10.3061
f15	447.2716	3021.2490	2493.8254	2294.3239	768.0798
f16	504.9572	1907.7271	1131.5573	1134.0312	473.1206
f17	157.3421	2015.0085	448.6463	528.1716	370.1393
f18	20.4177	73.7009	64.4063	61.0342	11.1425
f19	209.2898	1659.8942	727.2392	843.8771	437.9974
f20	530.0024	577.4796	552.9203	554.7086	10.9797
f21	100.0000	1.3677e+04	1.2747e+04	7388.0769	6598.7618
f22	726.8449	802.9851	772.2638	766.3361	18.9653
f23	792.9222	854.9906	839.0274	835.3793	14.6299
f24	480.2350	568.2142	480.3737	499.5745	31.2140
f25	1296.9531	4598.6212	4227.2025	4076.8170	646.3637
f26	485.5797	528.8619	510.3839	509.3493	10.9505
f27	458.8487	511.1135	458.8487	464.8470	16.5881
f28	408.9826	1267.9143	458.6715	572.2938	258.2466
f29	5.7942e+05	6.4938e+05	5.7944e+05	5.8613e+05	1.5331e+04

Table S4. Results of DE for 100D.

Func.	Best	Worst	Median	Mean	Std
f1	9.7859	3.5527e+04	4056.9094	6297.5872	7831.9493
f2	2.7528e+05	3.6729e+05	3.0643e+05	3.1040e+05	2.4113e+04
f3	134.7413	292.8981	200.7000	209.5581	35.0422
f4	738.4907	845.0100	810.0697	810.3526	22.6946
f5	1.3040e-05	3.7530e-03	1.4883e-04	5.6554e-04	9.1440e-04
f6	880.1872	963.2818	930.8019	928.8761	23.6022
f7	776.4191	857.9027	822.9840	820.0319	17.8679
f8	0.5439	20.1691	3.9927	5.1992	4.5353
f9	2.8251e+04	3.0107e+04	2.9594e+04	2.9428e+04	445.1559
f10	515.5531	687.3594	597.8934	594.3109	47.1077
f11	1.4272e+05	3.8121e+05	2.1106e+05	2.3340e+05	6.5851e+04
f12	364.6241	7878.4945	1909.4210	2991.2022	2776.1175
f13	1016.0796	2.0522e+04	6574.2241	8384.7757	5890.2600
f14	40.3965	1.0964e+04	618.5541	1751.4844	2841.7035
f15	7185.7674	8025.7307	7554.0732	7583.3327	223.0941
f16	2072.2606	5256.5787	4624.6306	4480.2291	576.2551
f17	3.1517e+04	1.9319e+05	1.1739e+05	1.1745e+05	4.4592e+04
f18	46.3759	9623.7890	1332.4397	2110.0363	2409.4343
f19	4115.7403	4918.8955	4560.3897	4553.5300	218.6408
f20	1008.3673	1071.3201	1046.3236	1042.7436	19.3117
f21	2.8441e+04	3.0906e+04	3.0407e+04	3.0203e+04	605.8924
f22	581.5883	1307.3465	608.0603	722.0095	244.3876
f23	924.2020	1703.5292	1611.3128	1454.4970	301.6624
f24	660.3272	824.4533	716.1510	734.3601	47.1616
f25	3378.1520	1.0995e+04	3650.7642	4799.6004	2637.6651
f26	562.8634	636.0635	594.2243	594.9174	16.9963
f27	480.4083	609.2470	552.8593	558.0172	27.5655
f28	1316.5120	5639.8922	4758.5738	4470.9011	1180.9155
f29	2380.4389	9294.5162	3053.4337	3949.8511	1967.5551

Table S5. Results of NL-SHADE-LBC for 10D.

Func.	Best	Worst	Median	Mean	Std
f1	0	0	0	0	0
f2	0	0	0	0	0
f3	0	5.4463e-02	0	3.6502e-03	1.1724e-02
f4	0	3.9798	1.0058	1.5139	0.9567
f5	0	0	0	0	0
f6	10.4614	15.1986	11.8252	12.0507	1.1680
f7	2.0600e-06	2.9849	0.9951	1.1962	0.9946
f8	0	0	0	0	0
f9	0.1877	144.2744	3.6829	24.5309	46.4259
f10	0	0	0	0	0
f11	0	236.8767	118.4383	76.0814	67.4265
f12	0	5.2041	1.1205	2.3574	2.4105
f13	0	0	0	0	0
f14	1.5974e-04	0.5000	0.2780	0.2581	0.2404
f15	0.2347	0.9937	0.5574	0.6083	0.1779
f16	0.1217	1.7898	0.7330	0.8298	0.4988
f17	2.0364e-04	0.5000	0.4653	0.3635	0.1861
f18	0	0.1217	1.9734e-02	2.7342e-02	3.1119e-02
f19	0	0.6243	0	8.7409e-02	0.1691
f20	100.0000	203.2624	102.7871	148.8940	51.7224
f21	100.0000	100.0000	100.0000	100.0000	0
f22	300.0000	302.8816	300.0000	300.2305	0.7979
f23	100.0000	329.5443	327.1647	269.2974	97.5188
f24	397.7429	443.3896	397.7429	414.2546	22.2686
f25	300.0000	300.0000	300.0000	300.0000	0
f26	393.8188	393.8188	393.8188	393.8188	0
f27	300.0000	583.7452	300.0000	322.6996	78.5655
f28	228.2107	240.6521	231.7708	232.6514	3.5731
f29	394.5008	407.4710	394.6675	400.2282	6.5360

Table S6. Results of NL-SHADE-LBC for 30D.

Func.	Best	Worst	Median	Mean	Std
f1	0	0	0	0	0
f2	0	0	0	0	0
f3	2.6697	87.1928	67.4443	51.4631	33.8437
f4	10.6228	31.3332	20.0895	19.3069	4.8487
f5	0	8.7000e-07	0	5.7600e-08	1.7707e-07
f6	39.4310	64.4267	50.1216	50.9424	6.1380
f7	8.8457	30.3878	17.5792	17.9933	5.5741
f8	0	0	0	0	0
f9	2013.1095	3827.9258	3184.3713	3107.8460	464.4489
f10	3.7295	14.9608	9.1150	9.1095	2.6500
f11	24.2516	1401.9791	879.3028	833.3108	295.2821
f12	6.6197	86.6450	21.9913	22.3391	15.3040
f13	21.7732	35.7846	26.3925	26.6140	2.7198
f14	2.3159	9.5597	4.5755	5.3499	2.2881
f15	6.2491	378.9796	140.0090	129.0945	108.9611
f16	27.3579	66.9841	46.2353	46.1762	8.7064
f17	20.7112	26.6472	23.4156	23.1370	1.4635
f18	5.6252	12.6471	8.5932	8.3837	1.8760
f19	32.6665	187.9168	45.7003	63.5139	43.4577
f20	206.9290	229.9435	217.7573	217.5997	5.1093
f21	100.0000	100.0000	100.0000	100.0000	0
f22	337.6775	375.0897	348.6371	350.7964	9.5349
f23	402.4122	432.5580	416.4408	416.2867	7.7109
f24	386.7100	386.9110	386.7614	386.7655	4.7795e-02
f25	200.0000	1152.2920	930.2726	737.5673	373.2866
f26	486.6909	512.6195	500.1156	499.7831	5.8935
f27	300.0000	392.7328	300.0000	311.0487	30.5375
f28	447.7976	527.8498	479.4183	478.0265	18.8119
f29	1992.0754	2175.7471	2047.7109	2072.2856	56.6312

Table S7. Results of NL-SHADE-LBC for 50D.

Func.	Best	Worst	Median	Mean	Std
f1	1.4199e-04	5468.0521	7.5286e-03	446.0240	1289.1644
f2	2.9400e-06	1.0809e-04	1.5250e-05	2.3052e-05	2.5182e-05
f3	28.5133	212.4989	140.1614	130.1655	61.4148
f4	31.8848	82.8450	49.9619	52.3782	13.5991
f5	5.0000e-08	1.0780e-05	3.8000e-07	1.0200e-06	2.1667e-06
f6	68.4788	157.6977	109.4798	109.0697	18.5324
f7	31.3202	80.5322	46.6572	48.0256	12.7000
f8	0	0	0	0	0
f9	4462.0751	7263.9881	6089.2598	5944.3653	675.2434
f10	33.9366	58.2548	42.9975	43.4862	5.9622
f11	2298.0081	2.0096e+04	8841.3302	8703.7359	4520.5511
f12	109.4508	253.6504	150.0402	158.4886	36.5454
f13	29.8016	50.2093	39.1068	39.2760	4.9553
f14	21.8698	81.6267	41.7746	43.6299	11.7375
f15	313.4346	835.5148	437.3490	469.6316	117.3607
f16	247.6362	629.2927	366.0019	398.8502	135.0110
f17	27.7566	71.0152	35.5170	37.5491	9.1491
f18	18.6082	33.1143	27.2346	26.9612	3.4182
f19	110.6174	438.0147	167.5826	187.9146	71.0948
f20	221.0522	276.2285	246.5384	248.0946	12.7168
f21	100.0000	100.0000	100.0000	100.0000	0
f22	416.9309	461.2110	439.0623	438.5383	10.1365
f23	485.7439	511.3324	493.8561	494.7646	6.3696
f24	480.3251	568.7740	529.3994	531.8495	22.5964
f25	1096.9533	1416.9710	1259.4781	1257.0443	84.4990
f26	495.2691	544.6494	520.7759	522.7851	13.8136
f27	458.8487	507.7411	465.2141	482.5595	24.6988
f28	455.0013	592.2384	536.7844	533.8714	36.4854
f29	6.1009e+05	6.9136e+05	6.2055e+05	6.3375e+05	2.5923e+04

Table S8. Results of NL-SHADE-LBC for 100D.

Func.	Best	Worst	Median	Mean	Std
f1	128.9120	8196.9638	3508.7243	3789.3834	1978.4547
f2	0.8051	4.9864	2.4172	2.4705	1.3065
f3	151.5246	287.7064	223.1468	214.5650	32.5433
f4	62.3835	157.3689	118.0233	112.6124	26.1156
f5	2.1800e-05	9.4099e-03	8.0210e-05	1.5557e-03	2.5687e-03
f6	204.3341	350.3747	261.6355	257.7910	38.2710
f7	79.2962	239.2028	119.1127	125.5560	36.0287
f8	0	2.7681	8.9528e-02	0.3229	0.5661
f9	1.2359e+04	1.7789e+04	1.4868e+04	1.5017e+04	1211.8675
f10	210.2424	473.3475	361.8050	359.9170	75.0328
f11	5.7896e+04	2.6130e+05	1.6119e+05	1.4960e+05	4.6247e+04
f12	1490.3770	4063.4725	2456.8836	2574.2139	686.0129
f13	153.6072	239.9852	208.1321	200.0500	23.1853
f14	169.6958	348.8291	257.5971	252.5833	44.6028
f15	846.6024	2574.9948	1838.7027	1744.2329	485.1380
f16	688.4716	2058.9863	1377.7503	1401.3738	288.0038
f17	140.1936	313.9776	226.0280	231.3133	47.4005
f18	136.9191	200.8068	161.2838	161.0154	17.8223
f19	1152.1307	2146.4937	1773.8547	1730.8748	273.3240
f20	268.1035	355.2668	301.5221	303.2746	21.2003
f21	100.0000	103.3124	100.0000	100.2357	0.8135
f22	576.1158	623.1419	602.3208	602.1453	12.7493
f23	821.6432	915.8549	868.5814	866.7395	22.9737
f24	713.2985	856.9269	788.4323	790.6450	46.9775
f25	3165.6330	3614.0782	3364.5481	3366.0191	105.7495
f26	606.5885	654.6789	632.2529	631.9551	12.5131
f27	547.1859	634.7857	591.8623	590.0760	19.9774
f28	1267.5581	2178.0905	1499.8146	1590.7621	224.1107
f29	2330.8767	3120.4816	2686.3829	2729.2891	207.6445

Table S9. Results of L-SHADE for 10D.

Func.	Best	Worst	Median	Mean	Std
f1	0	0	0	0	0
f2	0	0	0	0	0
f3	0	0	0	0	0
f4	0	2.9898	2.9853	2.3889	0.9529
f5	0	0	0	0	0
f6	11.1229	14.4390	12.0089	12.2979	0.8457
f7	2.7814e-04	3.9821	1.9973	2.4300	1.1508
f8	0	0	0	0	0
f9	0.4666	133.8425	7.3783	30.9700	48.2427
f10	0	1.2825	0	5.1301e-02	0.2565
f11	0	135.0661	0.4163	49.2422	61.3350
f12	0	6.2316	4.8371	3.7300	2.2487
f13	0	2.9849	0.9950	0.8756	0.8768
f14	2.2900e-05	0.5000	2.6538e-02	0.1771	0.2202
f15	5.6313e-02	0.7541	0.3604	0.3661	0.1806
f16	4.1206e-04	0.3679	3.3304e-02	7.2543e-02	0.1054
f17	9.2200e-06	0.5000	0.1055	0.2180	0.2293
f18	0	2.3229e-02	2.7556e-03	9.7401e-03	1.0164e-02
f19	0	0.3122	0	1.2487e-02	6.2435e-02
f20	100.0000	205.5741	201.7681	153.9348	52.8933
f21	100.0000	100.0000	100.0000	100.0000	0
f22	300.0000	306.2680	303.4061	303.3605	1.5604
f23	18.9172	333.5335	330.9321	281.8621	102.1269
f24	397.7429	443.3651	398.0090	407.0054	18.5448
f25	300.0000	300.0000	300.0000	300.0000	0
f26	389.0055	389.5180	389.5180	389.4360	0.1917
f27	300.0000	611.8218	300.0000	323.8222	82.5506
f28	226.8496	257.3043	231.9661	233.0345	5.6449
f29	394.5008	442.6603	394.5017	406.0613	20.9908

Table S10. Results of L-SHADE for 30D.

Func.	Best	Worst	Median	Mean	Std
f1	0	0	0	0	0
f2	0	0	0	0	0
f3	58.5616	58.5616	58.5616	58.5616	0
f4	3.2384	9.0948	6.1671	6.2390	1.3356
f5	0	1.4000e-07	0	0	2.8000e-08
f6	33.5730	39.8843	37.0371	36.7941	1.5230
f7	3.0890	9.2841	7.0447	6.8960	1.6165
f8	0	0	0	0	0
f9	1074.1049	1699.6638	1443.3837	1432.6952	183.6701
f10	2.9849	67.1756	6.9715	20.2044	24.8736
f11	375.5957	1585.9288	910.1703	928.3721	333.7573
f12	2.9849	34.0350	17.6830	17.0708	6.6718
f13	20.2167	25.8641	22.0762	22.5913	1.5375
f14	0.4364	8.4827	3.3897	3.2988	1.7304
f15	18.5393	247.4915	27.6900	47.7179	59.4212
f16	9.4800	40.5746	33.3438	32.3157	6.4721
f17	20.4339	28.5045	22.4596	22.4801	1.7324
f18	2.4083	10.8297	6.5986	6.5498	2.2525
f19	18.4344	39.2143	32.3492	31.5566	5.0350
f20	204.4470	211.4263	207.6562	207.3123	1.4614
f21	100.0000	100.0000	100.0000	100.0000	0
f22	345.7987	355.9081	352.1147	351.2940	3.1897
f23	423.5745	430.8756	427.2794	427.0784	1.7605
f24	386.7030	386.7979	386.7468	386.7476	2.3177e-02
f25	847.6107	1041.1500	944.1653	946.8633	44.9255
f26	494.8906	511.1461	505.3715	504.8657	4.3533
f27	300.0000	453.9302	300.0000	350.4645	58.7948
f28	418.1604	445.6428	432.6261	433.4178	7.4029
f29	1945.5644	2118.1853	1971.2282	2012.3672	56.2073

Table S11. Results of L-SHADE for 50D.

Func.	Best	Worst	Median	Mean	Std
f1	0	0	0	0	0
f2	0	0	0	0	0
f3	8.0547	142.3052	69.7119	73.2573	49.3131
f4	9.7801	15.2551	11.6752	11.9128	1.4974
f5	0	1.6400e-06	5.0000e-08	2.2160e-07	3.6347e-07
f6	59.8248	67.3852	63.9876	63.9635	1.6528
f7	8.9182	14.5099	11.2217	11.8030	1.8240
f8	0	0	0	0	0
f9	2587.8926	3600.0500	3064.6793	3083.9943	288.0892
f10	30.2043	75.9723	46.1237	47.6132	9.5137
f11	1526.2580	3139.7787	2120.6219	2189.6099	461.3564
f12	17.1769	122.7203	53.5314	49.5593	23.1053
f13	24.0023	35.9964	29.3064	29.5436	2.8117
f14	25.9766	60.2021	38.8991	40.9693	10.1333
f15	155.3567	611.3541	414.9066	421.1741	119.6196
f16	71.9151	406.0291	236.7278	237.7848	73.5914
f17	25.7243	72.4467	37.7754	38.9370	10.9603
f18	14.6466	35.5933	21.1150	22.3873	4.7890
f19	89.7297	248.5788	145.7722	151.6024	47.4918
f20	208.3652	218.7702	213.0771	212.9126	2.2643
f21	101.7272	4125.7790	3489.9540	2517.2818	1699.7981
f22	419.6152	442.3734	433.4764	433.0571	4.4352
f23	503.0554	512.5071	508.3890	508.5951	2.5936
f24	480.2350	492.0678	480.2962	481.7015	3.8593
f25	1089.7301	1284.2403	1164.2463	1174.1354	51.2574
f26	508.1107	599.9784	533.0332	537.4280	21.6862
f27	458.8487	507.6947	458.8487	469.9104	20.1846
f28	330.2522	370.2124	357.5012	354.6931	10.8992
f29	5.7941e+05	8.8805e+05	6.5165e+05	6.7384e+05	7.6393e+04

Table S12. Results of L-SHADE for 100D.

Func.	Best	Worst	Median	Mean	Std
f1	0	0	0	0	0
f2	1.2800e-06	3.0700e-05	4.4200e-06	8.7932e-06	7.6439e-06
f3	185.5078	212.2782	197.3568	197.8145	5.6944
f4	20.4028	43.4932	36.4405	35.3124	5.4375
f5	2.4752e-04	2.1683e-02	5.3775e-03	5.5580e-03	4.1868e-03
f6	132.9381	156.8765	140.7674	141.5592	5.0275
f7	16.9143	45.6269	34.9629	34.2679	6.3971
f8	0	1.0877	0.1791	0.3580	0.3436
f9	9509.2027	1.1325e+04	1.0317e+04	1.0360e+04	489.7228
f10	201.7437	566.8885	451.4756	443.5645	100.5577
f11	1.2180e+04	5.4217e+04	2.3140e+04	2.5826e+04	1.1572e+04
f12	184.5136	981.3908	402.5987	442.3133	177.3013
f13	204.0689	313.5110	253.8136	254.2917	27.5606
f14	179.8293	325.6354	240.8732	245.8834	45.5826
f15	1040.0660	2260.5589	1708.3757	1714.4103	349.2996
f16	717.2834	1570.1054	1189.7560	1155.2812	199.7139
f17	144.1333	401.4975	207.8250	231.5409	76.4706
f18	146.2790	256.3809	176.8494	183.7904	28.1862
f19	1270.8160	1865.2676	1548.8551	1537.8810	145.7492
f20	251.0861	269.6664	261.5115	260.3477	5.2174
f21	1.0390e+04	1.2456e+04	1.1300e+04	1.1302e+04	533.0979
f22	545.7921	588.6955	567.0211	567.2957	11.0164
f23	900.5254	931.1206	917.9677	917.0408	7.4563
f24	637.4083	774.3119	761.9122	748.1654	32.9379
f25	3159.1627	3566.5463	3408.0043	3404.1985	91.1360
f26	613.2316	673.3665	644.1791	642.8834	16.5419
f27	478.1864	573.4600	520.0708	520.6894	19.7827
f28	918.4482	1612.0754	1254.2177	1272.2918	189.8095
f29	2127.9188	2724.8673	2328.8125	2340.6329	141.2308

Table S13. Results of jSO for 10D.

Func.	Best	Worst	Median	Mean	Std
f1	0	0	0	0	0
f2	0	0	0	0	0
f3	0	0	0	0	0
f4	0	2.9849	1.9899	1.5521	0.8164
f5	0	0	0	0	0
f6	10.5977	13.6898	11.9125	11.9474	0.5542
f7	0	3.9798	1.9899	1.9899	0.8124
f8	0	0	0	0	0
f9	3.5399	131.6966	11.8920	32.4858	46.7644
f10	0	0	0	0	0
f11	0.2081	0.6244	0.4163	0.3580	0.1412
f12	0	5.5841	4.8371	3.2180	2.3938
f13	0	0.9950	0	3.9798e-02	0.1990
f14	1.2747e-03	0.5000	0.1951	0.2653	0.2056
f15	4.2704e-02	1.1437	0.5021	0.5638	0.2759
f16	9.1763e-03	1.1205	0.3863	0.4262	0.2664
f17	1.9200e-06	0.5000	0.3391	0.2865	0.2186
f18	0	3.9161e-02	0	9.3511e-03	1.2751e-02
f19	0	0.6243	0.3122	0.3871	0.1632
f20	0	203.9504	100.0000	145.2757	59.5918
f21	100.0000	100.0000	100.0000	100.0000	0
f22	300.0000	304.3168	300.0000	300.6974	1.4499
f23	100.0000	331.1380	328.5885	264.9539	104.9940
f24	397.7429	443.3459	398.0090	408.8673	19.7697
f25	300.0000	300.0000	300.0000	300.0000	0
f26	389.0055	389.5180	389.5180	389.4360	0.1917
f27	300.0000	611.8218	300.0000	324.9457	86.3395
f28	227.0627	242.2929	235.5079	235.1833	3.7476
f29	394.5008	394.6821	394.5017	394.5191	4.6988e-02

Table S14. Results of jSO for 30D.

Func.	Best	Worst	Median	Mean	Std
f1	0	0	0	0	0
f2	0	0	0	0	0
f3	58.5616	58.5616	58.5616	58.5616	0
f4	4.9765	13.9370	8.9566	8.5503	1.9831
f5	0	1.4000e-07	0	1.1200e-08	3.8764e-08
f6	35.4787	41.8950	39.2043	38.9737	1.6484
f7	5.9699	13.0507	8.9548	9.1448	1.8277
f8	0	0	0	0	0
f9	917.9237	1815.1522	1486.9905	1464.8674	248.8887
f10	4.0077e-04	7.2264	2.1303	2.8312	2.0799
f11	3.9332	592.4910	129.8908	216.3273	167.1318
f12	2.5546	24.1483	17.8546	17.0228	5.2018
f13	2.1418	24.0771	21.1982	20.0149	5.4341
f14	0.4174	4.1581	1.1362	1.3631	0.9776
f15	5.2789	239.3121	25.6056	66.9240	72.1669
f16	22.5891	48.8934	34.6314	36.3462	6.8523
f17	20.5148	22.7465	20.6972	20.9854	0.5952
f18	2.0381	8.4019	4.6260	4.5346	1.5415
f19	13.2847	41.4104	29.7818	29.3567	5.6791
f20	204.1181	212.5563	208.4025	208.5554	2.3110
f21	100.0000	100.0000	100.0000	100.0000	0
f22	343.0305	354.7455	350.0965	349.6782	2.9115
f23	422.5641	429.4680	425.5873	425.8976	1.7728
f24	386.6878	386.7198	386.6951	386.6972	8.4031e-03
f25	856.4833	1050.7688	942.9140	944.7799	45.1769
f26	473.0611	507.0570	493.5668	493.9173	7.8760
f27	300.0000	413.9752	300.0000	312.8219	35.4825
f28	356.9618	454.9137	434.1823	425.6575	27.0707
f29	1955.0306	2002.4599	1970.5645	1971.9225	11.0916

Table S15. Results of jSO for 50D.

Func.	Best	Worst	Median	Mean	Std
f1	0	0	0	0	0
f2	0	0	0	0	0
f3	3.8914	142.3052	28.5127	42.7048	37.3117
f4	10.9766	25.0657	16.3467	16.6778	3.0663
f5	0	2.9500e-06	1.9000e-07	4.6960e-07	7.1185e-07
f6	59.6859	74.8851	66.8380	67.0418	3.1429
f7	9.9497	23.8903	17.0311	17.4339	3.3116
f8	0	0	0	0	0
f9	2409.2337	3751.7262	3137.9058	3157.7247	324.3247
f10	22.2474	34.1697	30.1474	28.9525	3.1583
f11	1074.2954	2794.0989	1866.0751	1824.4905	461.1686
f12	6.5438	83.2514	38.5324	31.8991	21.5073
f13	21.1680	28.6228	25.4117	25.3399	2.2669
f14	21.0821	33.0164	24.4855	24.9593	2.9070
f15	137.5953	630.7063	398.9731	411.9340	131.0004
f16	95.8870	413.2433	253.7274	264.6026	81.8682
f17	20.4501	29.3601	24.0448	24.3531	1.9339
f18	9.8672	16.6094	12.7756	12.7583	1.7861
f19	63.7271	322.6272	114.2343	155.5696	81.0373
f20	209.0155	222.1369	217.6852	217.3475	3.0116
f21	100.0000	4355.0712	100.0000	1460.2533	1858.3801
f22	412.0508	441.1724	433.0434	432.0560	6.6002
f23	501.1407	519.4536	505.3591	507.0193	4.5214
f24	477.3482	491.8604	480.2566	482.9205	5.1481
f25	1080.3518	1229.6411	1143.1394	1151.0770	40.8196
f26	490.4654	530.0116	506.2112	507.1303	10.9111
f27	458.8487	458.8487	458.8487	458.8487	0
f28	339.9517	388.4087	362.4322	363.2761	12.4372
f29	5.7941e+05	6.9135e+05	5.9825e+05	5.9977e+05	2.5149e+04

Table S16. Results of jSO for 100D.

Func.	Best	Worst	Median	Mean	Std
f1	0	0	0	0	0
f2	2.3000e-07	6.5200e-06	1.3100e-06	1.8924e-06	1.7066e-06
f3	113.3220	212.2769	197.3568	192.1875	22.7492
f4	29.9631	51.7228	42.3270	42.1795	6.0242
f5	6.9000e-06	2.6363e-03	4.4260e-05	4.6008e-04	8.2696e-04
f6	134.3148	165.9674	146.8902	148.2234	8.7664
f7	28.0792	56.6779	42.9089	42.6103	6.2833
f8	0	0.5439	0	7.6006e-02	0.1628
f9	8381.3166	1.0752e+04	9766.4228	9682.9285	559.0376
f10	53.8071	179.3646	108.2196	110.4749	35.1581
f11	6517.7579	4.1748e+04	1.6453e+04	1.7567e+04	8198.7151
f12	103.8041	230.3778	148.8554	153.5380	32.9257
f13	44.9356	81.9290	58.8711	61.7553	12.4284
f14	93.5752	217.8631	161.6358	158.0054	33.8829
f15	1169.5338	2395.5797	1738.7254	1770.3289	326.2236
f16	757.6563	1633.1086	1351.9614	1319.4011	196.5215
f17	106.5154	245.0514	188.2544	180.8979	42.8708
f18	67.9980	147.0263	102.5831	101.1701	17.9910
f19	929.8962	1954.7371	1359.8047	1368.5323	242.2703
f20	254.4704	275.4322	264.4227	263.7504	6.5101
f21	8156.0769	1.1704e+04	1.0657e+04	1.0547e+04	818.2048
f22	541.3964	586.5060	568.7567	565.5059	12.3325
f23	877.1052	916.6279	901.4701	901.5313	9.7192
f24	637.2570	777.5303	703.9541	724.3528	42.8851
f25	3074.5358	3383.5527	3228.7205	3224.9706	90.0328
f26	532.0983	620.5703	577.9961	579.3070	26.2424
f27	478.1864	573.6137	518.7419	519.6381	24.6112
f28	820.3916	1598.2647	1258.1759	1248.7132	221.5815
f29	2097.9866	2706.4237	2336.8311	2333.5068	142.3203

Table S17. Results of jSOa for 10D.

Func.	Best	Worst	Median	Mean	Std
f1	0	0	0	0	0
f2	0	0	0	0	0
f3	0	0	0	0	0
f4	0	2.9849	1.9899	1.7909	0.8617
f5	0	0	0	0	0
f6	11.1054	13.5786	12.1652	12.1943	0.5616
f7	0	2.9850	1.9899	2.0297	0.8843
f8	0	0	0	0	0
f9	0.3747	128.7457	8.3085	35.2417	50.5558
f10	0	0	0	0	0
f11	0	0.6244	0.4163	0.3414	0.1791
f12	0	5.3947	4.8371	3.7141	2.1156
f13	0	0	0	0	0
f14	6.5356e-04	0.5000	0.2459	0.2406	0.2090
f15	2.6928e-02	0.8171	0.2299	0.2590	0.2203
f16	7.5499e-02	1.3942	0.4446	0.5451	0.3707
f17	8.1760e-05	0.5000	0.2474	0.2539	0.1983
f18	0	1.9432e-02	0	3.1091e-03	7.2707e-03
f19	0	0	0	0	0
f20	100.0000	204.8651	100.0000	137.4415	50.9534
f21	100.0000	100.0000	100.0000	100.0000	0
f22	300.0000	304.7050	300.0000	301.1592	1.7835
f23	100.0000	331.9766	329.3908	310.5727	63.4134
f24	397.7429	443.3651	398.0090	403.4395	15.0398
f25	300.0000	300.0000	300.0000	300.0000	0
f26	389.0055	389.5180	389.0055	389.0875	0.1917
f27	300.0000	611.8218	300.0000	395.2898	142.0036
f28	229.1139	244.9842	235.4710	235.1234	3.1523
f29	394.5008	8.1758e+05	394.5008	3.3084e+04	1.6344e+05

Table S18. Results of jSOa for 30D.

Func.	Best	Worst	Median	Mean	Std
f1	0	0	0	0	0
f2	0	0	0	0	0
f3	58.5616	58.5616	58.5616	58.5616	0
f4	5.9704	15.9193	10.9446	10.6711	2.2140
f5	0	0	0	0	0
f6	36.3727	44.1471	40.6371	40.6734	2.1644
f7	6.9647	14.9244	10.9634	11.1052	2.0450
f8	0	0	0	0	0
f9	946.0399	1849.7599	1441.6788	1401.0564	242.3856
f10	2.9518e-02	61.9691	1.7319	7.3828	16.5639
f11	0.4164	361.9023	135.3071	173.8704	96.9928
f12	14.5504	22.8950	19.6623	19.5126	2.5044
f13	1.3324	22.9638	8.2163	12.4298	9.4533
f14	0.4998	5.6319	3.7555	3.2748	1.6695
f15	13.7215	250.6680	24.7732	78.3172	86.9569
f16	13.4383	55.1825	33.5140	33.6280	8.2903
f17	0.9274	21.3883	20.6011	18.3776	6.3970
f18	2.5215	7.6316	4.5121	4.8114	1.3760
f19	12.6106	43.5816	31.4010	29.8792	6.8862
f20	207.2734	215.1004	210.8135	211.1109	2.1032
f21	100.0000	100.0000	100.0000	100.0000	0
f22	344.4081	359.1670	354.8956	354.0130	4.0485
f23	420.5020	433.8516	428.7614	428.2886	2.6501
f24	386.6878	386.7186	386.6930	386.6962	6.8096e-03
f25	859.6678	1010.7769	942.6383	942.8398	36.1056
f26	490.6479	509.6018	499.2219	500.0483	5.1002
f27	300.0000	413.9752	300.0000	309.1180	31.5583
f28	417.9362	454.9633	430.2987	431.3741	8.8601
f29	1941.5118	2002.4305	1970.3777	1965.7673	15.3502

Table S19. Results of jSOa for 50D.

Func.	Best	Worst	Median	Mean	Std
f1	0	0	0	0	0
f2	0	0	0	0	0
f3	0.6673	142.3052	28.5127	45.8142	45.0262
f4	13.9873	26.9460	20.2043	20.7446	3.6078
f5	0	3.8000e-07	0	2.9200e-08	7.6535e-08
f6	66.2862	78.6931	72.3078	72.2418	3.0433
f7	14.1421	25.1705	20.3061	19.9789	3.5861
f8	0	0	0	0	0
f9	2189.0360	3807.5959	3070.8689	3115.4971	365.5107
f10	21.8990	32.1374	28.1648	28.1008	2.3146
f11	1192.8317	2540.2427	1645.8279	1802.7792	429.2241
f12	8.3823	95.5174	43.1210	40.6065	20.4860
f13	21.4623	26.0637	23.8262	23.8261	1.1891
f14	18.1343	26.0747	22.0418	21.9799	2.1593
f15	137.2700	729.4690	488.3400	466.0163	137.8680
f16	107.5447	455.2142	265.3924	277.9023	101.6144
f17	20.7395	28.0031	24.2006	24.4940	2.0236
f18	7.1738	15.2075	9.9269	10.3427	1.8853
f19	51.0630	398.3839	87.1402	110.8397	76.9635
f20	214.4242	232.0522	222.3797	223.8606	4.3609
f21	100.0000	4245.4665	3284.6761	2799.2419	1422.9480
f22	424.1383	446.4110	437.5032	435.5713	6.2634
f23	498.4876	521.8733	514.0681	514.2893	5.3806
f24	480.2307	491.8424	480.2350	481.1687	3.2098
f25	1091.3818	1307.1750	1180.7308	1191.5331	53.0547
f26	490.5944	521.1301	508.7616	509.6175	7.4911
f27	458.8487	458.8487	458.8487	458.8487	0
f28	323.0713	385.9349	357.3989	356.6651	14.7402
f29	5.7941e+05	7.0171e+05	5.9825e+05	6.1019e+05	3.1774e+04

Table S20. Results of jSOa for 100D.

Func.	Best	Worst	Median	Mean	Std
f1	0	0	0	0	0
f2	0	1.0000e-08	0	0	0
f3	181.7177	212.2769	197.3568	198.7932	9.1992
f4	38.2163	57.2688	46.3025	46.9145	5.9748
f5	9.0000e-08	9.7800e-06	1.8100e-06	2.2232e-06	2.0497e-06
f6	133.4504	161.3774	147.5981	147.7772	7.5476
f7	29.7279	67.2856	43.4349	44.8855	10.1115
f8	0	0	0	0	0
f9	8276.8693	1.0779e+04	9785.1050	9646.9133	667.8245
f10	59.4668	218.1678	80.3668	96.6443	38.7642
f11	6977.2853	2.2003e+04	1.3888e+04	1.3590e+04	3958.2689
f12	133.3885	374.9141	206.9799	221.2587	60.4076
f13	47.0095	79.8107	55.8857	56.7635	8.4486
f14	103.8384	308.6067	169.4493	175.1721	50.8155
f15	1013.2591	2285.3138	1838.6859	1798.1378	317.5488
f16	826.4630	1615.5686	1275.7445	1271.3905	211.5288
f17	94.8000	241.7810	156.2516	159.4237	37.2490
f18	59.4175	114.5888	80.0601	83.1063	14.3667
f19	970.0182	1717.9090	1316.4072	1313.0477	223.5937
f20	252.1627	286.5887	267.3813	268.3065	8.6708
f21	8627.7762	1.1442e+04	1.0499e+04	1.0309e+04	812.3695
f22	539.4399	571.5886	555.6584	556.7488	7.7295
f23	895.0782	928.8434	910.7480	911.4239	9.0714
f24	661.0928	773.5398	714.8119	730.7854	33.0592
f25	3079.7285	3453.9071	3297.0812	3274.1567	99.8291
f26	552.7164	606.0959	583.5425	582.3296	15.1161
f27	478.1864	576.8615	521.6694	528.1392	33.1653
f28	938.3710	1696.2685	1326.0011	1346.2813	201.0848
f29	2147.9330	2832.8266	2438.6430	2456.5301	184.3797

Table S21. Results of mLSHADE-RL for 10D.

Func.	Best	Worst	Median	Mean	Std
f1	0	0	0	0	0
f2	0	0	0	0	0
f3	0	0	0	0	0
f4	0	2.9849	1.9899	1.5123	0.6499
f5	0	0	0	0	0
f6	11.0519	12.8191	11.8050	11.7726	0.4315
f7	0	2.9849	1.9899	1.6317	0.6965
f8	0	0	0	0	0
f9	0.2498	217.3895	15.2445	56.8732	64.7049
f10	0	0.9950	0	7.9597e-02	0.2755
f11	118.4383	533.6841	296.3149	275.6260	146.3067
f12	0	19.8991	6.1114	5.8789	4.2878
f13	0	21.1021	0.9950	2.3972	4.1607
f14	1.3749e-03	9.0871	1.0405	1.7718	2.3745
f15	0.1012	1.0704	0.4489	0.4850	0.2652
f16	1.9778e-02	1.0433	0.3319	0.3618	0.2975
f17	0.5000	25.2866	3.9497	6.7301	7.3549
f18	1.5836e-03	1.6492	5.8506e-02	0.2894	0.5333
f19	0	1.3071	2.5410e-05	0.2142	0.3375
f20	100.0000	203.5067	100.0000	140.9904	51.2395
f21	100.0000	100.0000	100.0000	100.0000	0
f22	300.0000	304.4718	300.0000	300.6769	1.4242
f23	100.0000	329.6450	327.0896	272.6529	99.0426
f24	397.7429	445.8020	399.5850	414.6527	22.1945
f25	300.0000	300.0000	300.0000	300.0000	0
f26	374.1764	387.0855	379.1668	379.6066	3.0065
f27	300.0000	498.4104	300.0000	307.9364	39.6821
f28	227.2468	237.7328	229.8222	230.2677	2.5301
f29	384.0827	544.1025	448.9487	449.7039	45.9723

Table S22. Results of mLSHADE-RL for 30D.

Func.	Best	Worst	Median	Mean	Std
f1	0	0	0	0	0
f2	0	0	0	0	0
f3	0	67.1994	3.9866	11.2900	21.3927
f4	10.9445	21.8891	14.9244	15.3145	2.6309
f5	0	2.3874e-02	0	9.5498e-04	4.7748e-03
f6	38.2489	66.5845	44.8416	47.5640	5.9889
f7	9.9496	26.8639	14.9244	15.3622	3.5536
f8	0	0	0	0	0
f9	465.3599	1889.7855	1502.2184	1432.4988	355.3524
f10	21.8891	54.7224	39.7982	39.0829	8.5813
f11	249.7775	1958.2607	1253.0723	1240.3611	392.4486
f12	16.5945	2423.2564	159.7258	586.6845	807.7230
f13	61.7906	110.5437	81.6876	79.1334	11.0709
f14	52.9697	343.1930	177.5936	179.5012	58.1325
f15	3.3459	317.8830	132.1502	112.6768	102.1177
f16	15.8302	52.5826	36.4305	38.0934	7.8419
f17	40.3973	218.5019	97.8813	110.0722	46.5540
f18	42.1747	134.6794	81.5184	80.8045	19.0310
f19	23.6973	62.7457	39.4025	40.3390	8.6815
f20	207.5551	220.7346	214.1759	214.0214	3.2087
f21	100.0000	102.4534	100.0000	100.0981	0.4907
f22	347.2544	368.6093	359.5766	359.6774	6.1270
f23	414.7977	431.6817	425.3429	425.4509	4.1712
f24	378.8667	388.1271	382.0504	383.3037	3.2514
f25	908.4094	1206.3172	1071.8117	1064.9932	66.4326
f26	465.6047	521.9135	500.0094	497.5626	15.0175
f27	300.0000	403.2857	300.0000	304.1314	20.6571
f28	425.0844	479.3598	441.3439	444.5895	11.8992
f29	1483.0238	2356.2711	1951.0875	1912.6248	261.4313

Table S23. Results of mLSHADE-RL for 50D.

Func.	Best	Worst	Median	Mean	Std
f1	0	8.0000e-08	0	0	1.8708e-08
f2	0	1.3000e-07	0	0	2.6000e-08
f3	0	101.6915	0	6.0790	21.0966
f4	18.9042	33.8286	28.8538	27.6997	4.3434
f5	1.8745e-04	4.0031e-02	9.2157e-03	1.1284e-02	1.0154e-02
f6	67.0110	91.7425	75.5862	76.3486	6.2520
f7	20.8941	38.8034	26.8639	27.6979	4.3910
f8	0	0.7229	0.2686	0.3244	0.2249
f9	1993.2790	3789.8528	3035.9380	3071.8217	467.5364
f10	74.5804	133.3664	106.3302	106.0686	14.2415
f11	1284.2771	1.3587e+04	2146.2496	2743.0793	2421.5774
f12	87.7853	1143.1540	369.1229	432.0870	265.5983
f13	140.3911	202.0840	171.2320	170.8393	14.3801
f14	219.8705	464.7615	323.4725	333.2286	53.3546
f15	244.5643	583.7467	365.4728	375.8249	89.5257
f16	229.4919	561.4386	397.7137	409.6369	89.9078
f17	30.7402	346.2208	144.7183	151.3762	91.6912
f18	50.3150	153.6032	90.5368	92.8490	22.6882
f19	65.1410	223.7661	101.0551	114.9480	42.8406
f20	218.3220	231.6823	226.2650	225.8018	3.0949
f21	100.0000	3671.3678	100.0000	243.8704	714.0639
f22	429.7271	460.6950	445.3983	444.0352	6.9757
f23	494.4222	536.9979	519.9498	519.8682	9.5723
f24	470.4390	570.8537	526.2120	526.5783	22.3243
f25	1287.2608	1626.4442	1427.6148	1425.6038	83.4545
f26	556.3211	700.1844	626.5473	626.1623	32.1868
f27	448.6645	506.1364	494.3941	492.3117	13.9791
f28	341.2206	511.6038	377.6525	386.4152	43.6382
f29	8.4744e+04	6.0467e+05	3.9342e+05	3.7569e+05	1.2512e+05

Table S24. Results of mLSHADE-RL for 100D.

Func.	Best	Worst	Median	Mean	Std
f1	0	7.1070e-05	2.4000e-07	6.0580e-06	1.9013e-05
f2	3.7000e-07	4.0100e-06	1.0300e-06	1.2748e-06	1.0005e-06
f3	0	181.4824	3.9866	16.9015	47.7588
f4	52.7328	105.4656	74.6219	75.4577	15.4049
f5	0.2806	1.3178	0.8114	0.7829	0.2771
f6	140.4934	184.7988	157.7754	157.4696	11.2971
f7	52.7328	98.5009	78.6017	78.0445	11.6990
f8	23.4323	129.2906	71.9286	66.7444	28.0271
f9	6255.4353	1.1477e+04	9480.7105	9269.8036	1207.0450
f10	566.8588	900.5329	729.0384	737.8702	83.3021
f11	2885.3865	5065.9910	4174.2219	4057.4105	598.5864
f12	292.0143	3539.7409	1568.6183	1768.2933	835.0585
f13	229.9352	418.9737	284.6598	297.4441	43.4561
f14	181.0820	371.3254	225.8357	236.0416	42.4894
f15	374.0936	1359.3632	674.0535	763.7935	258.3543
f16	672.4242	1389.5163	1146.0995	1109.9621	216.9268
f17	120.7526	520.7030	248.1413	255.4421	75.8978
f18	126.4246	243.3991	170.5321	172.0926	26.1405
f19	705.9838	1302.0756	1068.2998	1030.6390	165.4642
f20	277.3930	313.2615	301.3842	297.8885	11.0861
f21	7255.3102	1.1786e+04	9866.2612	9842.5794	1040.0384
f22	637.4601	720.2879	678.4703	677.0772	18.5202
f23	996.2100	1132.4603	1053.4361	1054.1494	32.1020
f24	635.4588	823.5423	720.2255	731.1289	51.0382
f25	4277.4454	5711.6960	5160.1666	5111.0151	343.0884
f26	798.7441	975.1566	880.3867	885.8019	41.2662
f27	300.0000	586.8291	518.6773	488.0857	98.8912
f28	1125.7477	2463.6382	1440.7475	1496.4028	265.0428
f29	1634.3136	2917.8641	2478.6629	2455.3722	270.9049

Table S25. Results of RDE for 10D.

Func.	Best	Worst	Median	Mean	Std
f1	0	0	0	0	0
f2	0	0	0	0	0
f3	0	0	0	0	0
f4	0	2.9849	1.9899	1.6317	0.8559
f5	0	0	0	0	0
f6	11.1717	14.2427	12.3870	12.5232	0.8457
f7	0	2.9849	1.9899	1.8307	0.8462
f8	0	0	0	0	0
f9	0.2498	245.2810	11.8295	63.5236	76.8476
f10	0	0	0	0	0
f11	0	119.7380	0.2081	9.8038	33.0867
f12	0	6.1411	4.8371	4.0209	1.9792
f13	0	0	0	0	0
f14	6.6450e-05	0.5000	0.3828	0.2778	0.2159
f15	4.9340e-05	1.1236	0.5141	0.5532	0.2837
f16	0	2.3021	0.3122	0.4191	0.5660
f17	4.5059e-04	0.5000	0.3782	0.2859	0.2065
f18	0	3.9161e-02	0	1.0918e-02	1.3907e-02
f19	0	0.3122	0.3122	0.1998	0.1529
f20	100.0000	205.1470	202.5800	174.1274	47.1958
f21	100.0000	100.2900	100.0000	100.0116	5.8000e-02
f22	300.0000	303.2140	300.0000	300.2316	0.8069
f23	100.0000	331.6630	327.9200	315.0948	45.8229
f24	397.7430	445.7780	443.3300	425.2806	22.7916
f25	300.0000	300.0000	300.0000	300.0000	0
f26	379.1810	388.8930	388.4070	386.2488	3.7483
f27	300.0000	500.0020	300.0000	311.8802	43.7236
f28	227.5620	236.3340	230.3020	230.6679	2.2371
f29	256.1160	394.6650	394.4950	361.2369	54.6691

Table S26. Results of RDE for 30D.

Func.	Best	Worst	Median	Mean	Std
f1	0	0	0	0	0
f2	0	0	0	0	0
f3	15.1767	24.4500	21.3989	21.5324	1.6874
f4	4.9749	11.9395	6.9651	7.5268	1.7051
f5	0	0	0	0	0
f6	34.7581	41.4163	38.2052	38.1523	1.7028
f7	3.9798	9.9496	6.9647	6.7268	1.6819
f8	0	0	0	0	0
f9	934.6210	1902.1200	1436.0800	1459.6300	243.0462
f10	0	21.8294	2.9849	4.9758	5.8395
f11	33.3906	580.1460	343.6000	304.7257	134.9219
f12	1.9374e-04	25.0861	14.9196	11.8832	8.0375
f13	2.8640e-02	25.1318	21.0415	17.6955	8.1127
f14	0.3699	2.4885	0.7934	1.0514	0.7563
f15	3.8686	137.6060	12.6507	22.3806	34.6797
f16	10.7618	49.4780	35.3498	34.5483	9.1569
f17	0.5421	22.5271	20.5871	20.2702	4.1838
f18	2.3812	5.3171	2.9980	3.2342	0.7574
f19	10.1638	45.9631	26.3792	27.7797	7.0005
f20	201.9870	211.3240	206.6420	206.7110	2.1671
f21	100.0000	100.0000	100.0000	100.0000	0
f22	344.1550	358.4860	348.2630	349.2343	3.7096
f23	420.1340	430.8620	425.0710	425.3997	2.5905
f24	378.4220	379.1580	378.6310	378.6640	0.1570
f25	839.4580	989.5470	911.1110	910.6206	38.7375
f26	453.7150	488.9160	473.3800	473.2578	7.6630
f27	300.0000	413.8680	300.0000	304.5547	22.7736
f28	363.7160	446.3990	390.0360	396.8799	26.0493
f29	436.3000	1601.5200	613.7810	760.0778	338.2119

Table S27. Results of RDE for 50D.

Func.	Best	Worst	Median	Mean	Std
f1	0	0	0	0	0
f2	0	0	0	0	0
f3	21.4065	141.8930	21.9650	47.6559	40.1144
f4	7.9637	21.3185	14.9303	14.4828	3.2964
f5	0	0	0	0	0
f6	60.1184	70.1644	64.4292	64.2986	2.4945
f7	5.9717	19.1124	13.1783	13.9689	3.3687
f8	0	0	0	0	0
f9	2269.9400	3915.9200	3075.2900	3125.8444	415.9888
f10	14.1694	30.2322	20.3275	21.5195	4.2126
f11	1270.6600	2235.3900	1663.6300	1688.9272	241.9574
f12	7.6830	110.1770	42.2110	35.6092	28.0484
f13	22.4407	31.7334	26.1852	25.7679	2.1453
f14	18.2033	29.7023	22.8383	23.0711	3.4311
f15	124.7040	485.9470	142.6580	220.4684	112.8607
f16	66.0791	267.3100	199.2860	164.5395	61.9805
f17	22.6380	29.6892	24.9274	25.1765	1.7141
f18	8.5234	16.2782	12.4482	12.3710	1.9261
f19	48.1451	297.7300	70.9727	82.5268	49.6671
f20	208.8360	221.8310	215.6030	215.0096	3.9790
f21	100.0000	4852.9500	2805.1800	1998.9925	1901.6635
f22	412.5810	446.6910	425.5180	426.4575	7.8831
f23	495.1050	511.2500	501.6740	502.2175	4.0548
f24	458.2580	516.3400	479.4280	481.9139	11.2951
f25	1006.2600	1240.1900	1107.5000	1109.1792	58.3099
f26	455.4650	500.0110	471.3900	472.2466	11.4154
f27	451.1650	452.3280	451.6820	451.7287	0.3012
f28	250.6930	369.9370	274.1870	282.9886	29.0471
f29	975.8270	5149.0600	1324.4200	1588.4159	950.8979

Table S28. Results of RDE for 100D.

Func.	Best	Worst	Median	Mean	Std
f1	0	0	0	0	0
f2	6.9000e-07	4.1290e-05	7.2900e-06	8.8992e-06	8.7904e-06
f3	8.4089e-02	215.9600	155.3770	141.4785	69.8658
f4	23.8790	52.5670	35.8185	37.7952	8.6644
f5	1.7300e-06	6.4303e-03	8.7500e-06	6.9621e-04	1.5476e-03
f6	152.2950	192.8780	161.3210	165.9225	11.3690
f7	26.8639	58.7446	39.7984	40.5163	9.3113
f8	0	0	0	0	0
f9	8358.7900	1.2587e+04	1.0621e+04	1.0705e+04	1040.2117
f10	73.2719	226.6860	120.0150	127.4252	32.5415
f11	7760.8500	3.1201e+04	1.4049e+04	1.4985e+04	5519.3048
f12	76.0499	205.4620	116.7450	120.3482	28.7880
f13	42.0711	90.7522	70.8096	68.8728	12.4394
f14	116.0200	284.9280	196.9970	199.1481	40.7206
f15	898.7020	2194.4200	1405.9500	1489.4465	310.7188
f16	537.5580	1303.6600	927.7600	975.5584	204.7189
f17	142.9990	282.3600	217.9700	217.3814	39.0105
f18	89.0543	162.0500	126.3370	123.4720	20.3652
f19	765.9690	1534.6000	1183.3500	1176.3211	216.3574
f20	246.9940	276.8120	257.3850	258.4600	6.9538
f21	9865.0100	1.2352e+04	1.1356e+04	1.1275e+04	617.6968
f22	541.8090	586.3690	564.1140	563.0788	10.2459
f23	865.2620	910.5420	890.9410	890.7376	10.4892
f24	682.7700	766.9270	742.9660	722.0891	30.9434
f25	2931.2600	3348.9600	3165.9600	3153.6880	96.4969
f26	500.0220	500.0230	500.0230	500.0226	5.0000e-04
f27	500.0210	500.0230	500.0220	500.0222	5.5377e-04
f28	620.6340	1242.8600	766.2520	836.3172	179.5924
f29	668.0760	1569.3400	954.5910	1005.7470	192.5951

Table S29. Results of L-SRTDE for 10D.

Func.	Best	Worst	Median	Mean	Std
f1	0	0	0	0	0
f2	0	0	0	0	0
f3	0	0	0	0	0
f4	0	2.9849	0	0.5970	0.9083
f5	0	1.4200e-06	0	7.1200e-08	2.9006e-07
f6	10.3669	12.9748	11.2793	11.4673	0.6654
f7	0	2.9849	0	0.6368	0.8063
f8	0	0	0	0	0
f9	0.1249	11.9544	3.5399	3.0686	3.2522
f10	0	0.9950	0	3.9798e-02	0.1990
f11	0	0.6244	0.4163	0.3330	0.1699
f12	0	5.3941	0	2.0541	2.5303
f13	0	0.9950	0	3.9798e-02	0.1990
f14	8.6790e-05	0.4977	6.1133e-02	0.1788	0.2075
f15	2.5787e-02	0.9354	0.4515	0.4851	0.2392
f16	0	20.7461	0.6441	2.4436	5.4894
f17	2.4737e-04	0.5000	0.2635	0.2544	0.2182
f18	1.9090e-02	1.9432e-02	1.9432e-02	1.9418e-02	6.8340e-05
f19	0	0.6243	0.3122	0.1873	0.1802
f20	100.0000	203.9870	100.0000	148.5540	51.5935
f21	0	100.0000	100.0000	88.0000	33.1662
f22	300.0000	304.1110	300.0000	300.5368	1.2692
f23	100.0000	329.5640	327.1650	309.6489	48.3034
f24	397.7430	443.3870	443.3300	421.5488	23.1593
f25	300.0000	300.0000	300.0000	300.0000	0
f26	389.0060	395.0750	393.8190	392.7898	1.8329
f27	300.0000	300.0000	300.0000	300.0000	0
f28	226.1410	235.1520	228.9790	229.9411	2.4689
f29	394.5010	8.1758e+05	394.5140	3.3084e+04	1.6344e+05

Table S30. Results of L-SRTDE for 30D.

Func.	Best	Worst	Median	Mean	Std
f1	0	0	0	0	0
f2	0	0	0	0	0
f3	3.7849e-03	64.1174	58.5616	56.4415	11.8102
f4	0.9950	5.9698	2.9849	3.0247	1.3918
f5	0	3.1000e-07	0	4.7200e-08	8.1370e-08
f6	33.2460	48.7413	34.8905	35.6441	2.9737
f7	0	5.9698	1.9899	2.3879	1.6748
f8	0	0	0	0	0
f9	7.5667	820.6910	358.9920	353.0682	215.5156
f10	0	4.9816	0	1.3152	1.9238
f11	6.9477e-02	4.2500	0.4164	1.2354	1.6410
f12	0	17.2256	13.3547	8.3630	7.0679
f13	0	20.2013	0	2.5406	6.6488
f14	4.8493e-02	1.4396	0.4462	0.4833	0.2934
f15	0.8134	13.4924	2.8581	5.6480	4.8270
f16	2.5651	25.9913	21.9152	20.9914	5.7463
f17	0.4709	20.7732	20.7019	16.6641	8.2539
f18	1.0378	3.2319	2.1126	2.1499	0.5330
f19	0.1041	139.4280	0.4164	15.1355	35.5399
f20	200.0000	204.5880	201.9240	202.3349	1.6802
f21	100.0000	100.0000	100.0000	100.0000	0
f22	332.4770	348.6950	340.1070	339.8694	4.1412
f23	408.1250	421.1190	415.8940	415.2960	3.8648
f24	386.6880	386.7080	386.6930	386.6938	4.9723e-03
f25	400.0000	832.9170	646.4720	632.2296	134.5711
f26	461.4940	476.6040	472.0490	471.4141	3.7771
f27	300.0000	403.2860	300.0000	304.1314	20.6572
f28	393.4960	413.6440	404.4390	403.1613	4.9710
f29	1954.8500	1988.2500	1981.1000	1980.9636	9.7653

Table S31. Results of L-SRTDE for 50D.

Func.	Best	Worst	Median	Mean	Std
f1	0	0	0	0	0
f2	0	0	0	0	0
f3	28.5127	28.5127	28.5127	28.5127	0
f4	2.9849	7.9597	4.9748	5.4524	1.7499
f5	0	2.9500e-06	7.3000e-07	8.4760e-07	6.9760e-07
f6	56.6380	196.4670	60.0457	72.4673	31.4814
f7	0	7.9597	5.9698	5.3330	2.0081
f8	0	0	0	0	0
f9	123.4970	1060.4900	344.4580	344.8417	216.4926
f10	18.2648	21.2497	19.2598	19.1006	0.7960
f11	8.6427	240.8710	31.1075	77.0034	69.7056
f12	0.3401	10.6354	4.0457	4.0849	2.3414
f13	20.2849	23.5060	22.2474	21.8578	0.8697
f14	17.1344	19.1951	17.1693	17.5995	0.6506
f15	121.0690	128.0660	124.3360	124.5750	1.3253
f16	24.5054	201.1720	38.0169	95.5854	73.4830
f17	20.5388	21.9163	20.9929	21.0169	0.2199
f18	3.2296	5.2908	4.1953	4.1287	0.5933
f19	21.4842	36.9023	25.1278	26.8822	4.5870
f20	201.6050	210.3510	206.3840	205.8958	2.2141
f21	100.0000	100.0000	100.0000	100.0000	0
f22	396.6590	413.7590	404.5860	404.6086	4.9329
f23	477.0170	493.0530	485.4650	485.0280	4.0001
f24	480.2310	480.2350	480.2310	480.2326	1.8276e-03
f25	400.0000	835.8030	616.1280	555.3640	139.9583
f26	457.2020	475.4990	462.0570	463.4620	4.9009
f27	458.8490	458.8490	458.8490	458.8490	0
f28	288.6870	314.2770	305.2630	303.7494	7.5392
f29	5.7941e+05	5.8167e+05	5.7942e+05	5.7952e+05	447.6272

Table S32. Results of L-SRTDE for 100D.

Func.	Best	Worst	Median	Mean	Std
f1	0.1880	4747.0800	17.3843	266.2949	950.0397
f2	4.7467e-04	6.7634e-03	1.7617e-03	2.6219e-03	1.9758e-03
f3	187.7670	212.3180	193.2660	198.8534	9.1726
f4	10.9445	23.8790	17.9093	17.1531	3.3159
f5	1.3790e-05	7.4490e-05	4.2140e-05	4.0989e-05	1.4181e-05
f6	109.4640	370.3450	115.6330	129.5865	52.7233
f7	10.9445	26.8639	15.9193	16.2775	3.4572
f8	0	0	0	0	0
f9	865.3530	3079.7600	1614.5100	1755.8422	690.3930
f10	10.3493	26.6527	19.7436	19.4251	3.8357
f11	903.3620	1.2517e+04	2553.9200	2955.2249	2538.5782
f12	27.7892	98.1791	47.7091	55.1004	22.5514
f13	24.5072	34.4721	26.5512	26.9336	1.9445
f14	17.8320	90.2438	82.3108	70.5866	26.1500
f15	13.4450	254.8760	131.8940	107.6484	68.6527
f16	34.1830	187.5570	49.0141	77.1003	55.3846
f17	23.2541	30.4750	26.4588	26.1629	1.8952
f18	11.6037	19.1371	14.6224	14.8924	2.0106
f19	153.9070	181.8260	164.8150	166.4518	6.6191
f20	228.6360	241.0680	234.7360	235.1817	2.7393
f21	100.0000	4026.5500	2297.4300	2333.5140	898.1361
f22	523.6190	562.3080	538.0230	539.6581	8.7249
f23	787.6440	835.4140	811.1730	813.3810	13.8438
f24	576.9820	704.3870	637.1470	639.1328	26.0012
f25	1770.9700	2376.5300	2155.6600	2156.0820	144.9626
f26	499.5170	547.4400	517.8930	519.3510	12.0397
f27	478.1870	524.2970	499.2530	500.3146	13.7598
f28	604.4560	808.9740	704.8990	702.8170	33.8451
f29	2029.3300	2099.9200	2067.0100	2063.6468	17.8164

Table S33. Performance comparison of L-SRTDE with other algorithms on 10D. + means that L-SRTDE performs significantly better than a compared algorithm.

Func.	DE		NL-SHADE-LBC		L-SHADE		jSO		jSOa		mLSHADE-RL		RDE		L-SRTDE	
	Mean	Std sig	Mean	Std sig	Mean	Std sig	Mean	Std sig	Mean	Std sig	Mean	Std sig	Mean	Std sig	Mean	Std
f1	0	0 ≈	0	0 ≈	0	0 ≈	0	0 ≈	0	0 ≈	0	0 ≈	0	0 ≈	0	0
f2	0	0 ≈	0	0 ≈	0	0 ≈	0	0 ≈	0	0 ≈	0	0 ≈	0	0 ≈	0	0
f3	1.0264e-03	5.1318e-03 ≈	3.6502e-03	1.1724e-02 +	0	0 ≈	0	0 ≈	0	0 ≈	0	0 ≈	0	0 ≈	0	0
f4	23.5513	3.3777 +	1.5139	0.9567 +	2.3889	0.9529 +	1.5521	0.8164 +	1.7909	0.8617 +	1.5123	0.6499 +	1.6317	0.8559 +	0.5970	0.9083
f5	0	0 ≈	0	0 ≈	0	0 ≈	0	0 ≈	0	0 ≈	0	0 ≈	0	0 ≈	7.1200e-08	2.9006e-07
f6	33.7499	3.6944 +	12.0507	1.1680 ≈	12.2979	0.8457 +	11.9474	0.5542 +	12.1943	0.5616 +	11.7726	0.4315 +	12.5232	0.8457 +	11.4673	0.6654
f7	23.3779	3.3567 +	1.1962	0.9946 +	2.4300	1.1508 +	1.9899	0.8124 +	2.0297	0.8843 +	1.6317	0.6965 +	1.8307	0.8462 +	0.6368	0.8063
f8	0	0 ≈	0	0 ≈	0	0 ≈	0	0 ≈	0	0 ≈	0	0 ≈	0	0 ≈	0	0
f9	972.2365	177.2143 +	24.5309	46.4259 +	30.9700	48.2427 +	32.4858	46.7644 +	35.2417	50.5558 +	56.8732	64.7049 +	63.5236	76.8476 +	3.0686	3.2522
f10	3.9883e-02	0.1990 +	0	0 ≈	5.1301e-02	0.2565 ≈	0	0 ≈	0	0 ≈	7.9597e-02	0.2755 ≈	0	0 ≈	3.9798e-02	0.1990
f11	0.3423	0.3748 ≈	76.0814	67.4265 +	49.2422	61.3350 ≈	0.3580	0.1412 ≈	0.3414	0.1791 ≈	275.6260	146.3067 +	9.8038	33.0867 ≈	0.3330	0.1699
f12	3.5732	2.9019 +	2.3574	2.4105 ≈	3.7300	2.2487 ≈	3.2180	2.3938 ≈	3.7141	2.1156 +	5.8789	4.2878 +	4.0209	1.9792 ≈	2.0541	2.5303
f13	0.2138	0.8639 +	0	0 ≈	0.8756	0.8768 +	3.9798e-02	0.1990 ≈	0	0 ≈	2.3972	4.1607 +	0	0 ≈	3.9798e-02	0.1990
f14	2.9625e-03	4.6535e-03 −	0.2581	0.2404 ≈	0.1771	0.2202 ≈	0.2653	0.2056 +	0.2406	0.2090 ≈	1.7718	2.3745 +	0.2778	0.2159 ≈	0.1788	0.2075
f15	0.3015	0.1617 −	0.6083	0.1779 +	0.3661	0.1806 ≈	0.5638	0.2759 ≈	0.2590	0.2203 −	0.4850	0.2652 ≈	0.5532	0.2837 ≈	0.4851	0.2392
f16	5.7228	6.0687 +	0.8298	0.4988 ≈	7.2543e-02	0.1054 −	0.4262	0.2664 −	0.5451	0.3707 ≈	0.3618	0.2975 −	0.4191	0.5660 −	2.4436	5.4894
f17	1.3213e-02	4.5822e-02 −	0.3635	0.1861 ≈	0.2180	0.2293 ≈	0.2865	0.2186 ≈	0.2539	0.1983 ≈	6.7301	7.3549 +	0.2859	0.2065 ≈	0.2544	0.2182
f18	6.2545e-03	1.1890e-02 −	2.7342e-02	3.1119e-02 +	9.7401e-03	1.0164e-02 ≈	9.3511e-03	1.2751e-02 −	3.1091e-03	7.2707e-03 −	0.2894	0.5333 +	1.0918e-02	1.3907e-02 −	1.9418e-02	6.8340e-05
f19	0.2123	0.1738 ≈	8.7409e-02	0.1691 −	1.2487e-02	6.2435e-02 −	0.3871	0.1632 +	0	0 −	0.2142	0.3375 ≈	0.1998	0.1529 ≈	0.1873	0.1802
f20	169.4712	62.9333 +	148.8940	51.7224 ≈	153.9348	52.8933 ≈	145.2757	59.5918 ≈	137.4415	50.9534 ≈	140.9904	51.2395 ≈	174.1274	47.1958 +	148.5540	51.5935
f21	96.1594	20.0346 +	100.0000	0 ≈	100.0000	0 ≈	100.0000	0 ≈	100.0000	0 ≈	100.0000	0 ≈	100.0116	5.8000e-02 +	88.0000	33.1662
f22	310.6149	5.9574 +	300.2305	0.7979 ≈	303.3605	1.5604 +	300.6974	1.4499 ≈	301.1592	1.7835 ≈	300.6769	1.4242 ≈	300.2316	0.8069 ≈	300.5368	1.2692
f23	256.4229	120.2072 ≈	269.2974	97.5188 ≈	281.8621	102.1269 +	264.9539	104.9940 ≈	310.5727	63.4134 +	272.6529	99.0426 ≈	315.0948	45.8229 ≈	309.6489	48.3034
f24	399.8407	9.5747 −	414.2546	22.2686 −	407.0054	18.5448 −	408.8673	19.7697 −	403.4395	15.0398 −	414.6527	22.1945 ≈	425.2806	22.7916 ≈	421.5488	23.1593
f25	300.0000	0 ≈	300.0000	0 ≈	300.0000	0 ≈	300.0000	0 ≈	300.0000	0 ≈	300.0000	0 ≈	300.0000	0 ≈	300.0000	0
f26	390.0890	1.6754 −	393.8188	0 +	389.4360	0.1917 −	389.4360	0.1917 −	389.0875	0.1917 −	379.6066	3.0065 −	386.2488	3.7483 −	392.7898	1.8329
f27	300.0000	0 ≈	322.6996	78.5655 ≈	323.8222	82.5506 ≈	324.9457	86.3395 ≈	395.2898	142.0036 +	307.9364	39.6821 ≈	311.8802	43.7236 ≈	300.0000	0
f28	240.1197	4.3986 +	232.6514	3.5731 +	233.0345	5.6449 +	235.1833	3.7476 +	235.1234	3.1523 +	230.2677	2.5301 ≈	230.6679	2.2371 ≈	229.9411	2.4689
f29	396.8685	4.8002 +	400.2282	6.5360 ≈	406.0613	20.9908 ≈	394.5191	4.6988e-02 −	3.3084e+04	1.6344e+05 −	449.7039	45.9723 +	361.2369	54.6691 −	3.3084e+04	1.6344e+05
+ / ≈ / −	13/10/6		9/18/2		8/17/4		7/17/5		8/15/6		11/16/2		6/19/4			

Table S34. Performance comparison of L-SRTDE with other algorithms on 30D. + means that L-SRTDE performs significantly better than a compared algorithm.

Func.	DE		NL-SHADE-LBC		L-SHADE		jSO		jSOa		mLSHADE-RL		RDE		L-SRTDE	
	Mean	Std sig	Mean	Std sig	Mean	Std sig	Mean	Std sig	Mean	Std sig	Mean	Std sig	Mean	Std sig	Mean	Std
f1	0	0 ≈	0	0 ≈	0	0 ≈	0	0 ≈	0	0 ≈	0	0 ≈	0	0 ≈	0	0
f2	12.1225	9.0058 +	0	0 ≈	0	0 ≈	0	0 ≈	0	0 ≈	0	0 ≈	0	0 ≈	0	0
f3	58.7838	1.1112 ≈	51.4631	33.8437 +	58.5616	0 ≈	58.5616	0 ≈	58.5616	0 ≈	11.2900	21.3927 −	21.5324	1.6874 −	56.4415	11.8102
f4	179.1810	8.5977 +	19.3069	4.8487 +	6.2390	1.3356 +	8.5503	1.9831 +	10.6711	2.2140 +	15.3145	2.6309 +	7.5268	1.7051 +	3.0247	1.3918
f5	0	0 ≈	5.7600e-08	1.7707e-07 ≈	0	2.8000e-08 −	1.1200e-08	3.8764e-08 ≈	0	0 −	9.5498e-04	4.7748e-03 ≈	0	0 −	4.7200e-08	8.1370e-08
f6	209.6285	9.8081 +	50.9424	6.1380 +	36.7941	1.5230 +	38.9737	1.6484 +	40.6734	2.1644 +	47.5640	5.9889 +	38.1523	1.7028 +	35.6441	2.9737
f7	181.2514	7.9663 +	17.9933	5.5741 +	6.8960	1.6165 +	9.1448	1.8277 +	11.1052	2.0450 +	15.3622	3.5536 +	6.7268	1.6819 +	2.3879	1.6748
f8	0	0 ≈	0	0 ≈	0	0 ≈	0	0 ≈	0	0 ≈	0	0 ≈	0	0 ≈	0	0
f9	6825.4268	211.4563 +	3107.8460	464.4489 +	1432.6952	183.6701 +	1464.8674	248.8887 +	1401.0564	242.3856 +	1432.4988	355.3524 +	1459.6300	243.0462 +	353.0682	215.5156
f10	50.1288	14.6796 +	9.1095	2.6500 +	20.2044	24.8736 +	2.8312	2.0799 +	7.3828	16.5639 +	39.0829	8.5813 +	4.9758	5.8395 +	1.3152	1.9238
f11	7149.2135	4524.5264 +	833.3108	295.2821 +	928.3721	333.7573 +	216.3273	167.1318 +	173.8704	96.9928 +	1240.3611	392.4486 +	304.7257	134.9219 +	1.2354	1.6410
f12	79.8439	9.0122 +	22.3391	15.3040 +	17.0708	6.6718 +	17.0228	5.2018 +	19.5126	2.5044 +	586.6845	807.7230 +	11.8832	8.0375 +	8.3630	7.0679
f13	63.6367	4.3095 +	26.6140	2.7198 +	22.5913	1.5375 +	20.0149	5.4341 +	12.4298	9.4533 +	79.1334	11.0709 +	17.6955	8.1127 +	2.5406	6.6488
f14	35.0112	9.1651 +	5.3499	2.2881 +	3.2988	1.7304 +	1.3631	0.9776 +	3.2748	1.6695 +	179.5012	58.1325 +	1.0514	0.7563 +	0.4833	0.2934
f15	735.2669	445.3031 +	129.0945	108.9611 +	47.7179	59.4212 +	66.9240	72.1669 +	78.3172	86.9569 +	112.6768	102.1177 +	22.3806	34.6797 +	5.6480	4.8270
f16	71.1435	7.2400 +	46.1762	8.7064 +	32.3157	6.4721 +	36.3462	6.8523 +	33.6280	8.2903 +	38.0934	7.8419 +	34.5483	9.1569 +	20.9914	5.7463
f17	36.0905	4.1997 +	23.1370	1.4635 +	22.4801	1.7324 +	20.9854	0.5952 ≈	18.3776	6.3970 ≈	110.0722	46.5540 +	20.2702	4.1838 ≈	16.6641	8.2539
f18	17.0103	6.3938 +	8.3837	1.8760 +	6.5498	2.2525 +	4.5346	1.5415 +	4.8114	1.3760 +	80.8045	19.0310 +	3.2342	0.7574 +	2.1499	0.5330
f19	25.2129	15.3827 +	63.5139	43.4577 +	31.5566	5.0350 +	29.3567	5.6791 +	29.8792	6.8862 +	40.3390	8.6815 +	27.7797	7.0005 +	15.1355	35.5399
f20	368.5389	7.5346 +	217.5997	5.1093 +	207.3123	1.4614 +	208.5554	2.3110 +	211.1109	2.1032 +	214.0214	3.2087 +	206.7110	2.1671 +	202.3349	1.6802
f21	100.0000	0 ≈	100.0000	0 ≈	100.0000	0 ≈	100.0000	0 ≈	100.0000	0 ≈	100.0981	0.4907 ≈	100.0000	0 ≈	100.0000	0
f22	519.9889	10.5863 +	350.7964	9.5349 +	351.2940	3.1897 +	349.6782	2.9115 +	354.0130	4.0485 +	359.6774	6.1270 +	349.2343	3.7096 +	339.8694	4.1412
f23	584.8942	10.2894 +	416.2867	7.7109 ≈	427.0784	1.7605 +	425.8976	1.7728 +	428.2886	2.6501 +	425.4509	4.1712 +	425.3997	2.5905 +	415.2960	3.8648
f24	386.7411	2.1635e-02 +	386.7655	4.7795e-02 +	386.7476	2.3177e-02 +	386.6972	8.4031e-03 ≈	386.6962	6.8096e-03 ≈	383.3037	3.2514 −	378.6640	0.1570 −	386.6938	4.9723e-03
f25	2258.4716	608.9886 +	737.5673	373.2866 +	946.8633	44.9255 +	944.7799	45.1769 +	942.8398	36.1056 +	1064.9932	66.4326 +	910.6206	38.7375 +	632.2296	134.5711
f26	490.6236	8.3162 +	499.7831	5.8935 +	504.8657	4.3533 +	493.9173	7.8760 +	500.0483	5.1002 +	497.5626	15.0175 +	473.2578	7.6630 ≈	471.4141	3.7771
f27	312.3943	34.2560 ≈	311.0487	30.5375 ≈	350.4645	58.7948 +	312.8219	35.4825 ≈	309.1180	31.5583 ≈	304.1314	20.6571 ≈	304.5547	22.7736 ≈	304.1314	20.6572
f28	540.3465	121.3232 +	478.0265	18.8119 +	433.4178	7.4029 +	425.6575	27.0707 +	431.3741	8.8601 +	444.5895	11.8992 +	396.8799	26.0493 ≈	403.1613	4.9710
f29	1987.7943	38.5875 ≈	2072.2856	56.6312 +	2012.3672	56.2073 ≈	1971.9225	11.0916 −	1965.7673	15.3502 −	1912.6248	261.4313 ≈	760.0778	338.2119 −	1980.9636	9.7653
+ / ≈ / −	22/7/0		22/7/0		22/6/1		19/9/1		19/8/2		20/7/2		17/8/4			

Table S35. Performance comparison of L-SRTDE with other algorithms on 50D. + means that L-SRTDE performs significantly better than a compared algorithm.

Func.	DE			NL-SHADE-LBC			L-SHADE			jSO			jSOa			mLSHADE-RL			RDE			L-SRTDE		
	Mean	Std sig		Mean	Std sig		Mean	Std sig		Mean	Std sig		Mean	Std sig		Mean	Std sig		Mean	Std sig		Mean	Std	
f1	77.1775	238.7580	+	446.0240	1289.1644	+	0	0	≈	0	0	≈	0	0	≈	0	1.8708e-08	≈	0	0	≈	0	0	
f2	5.6631e+04	1.2583e+04	+	2.3052e-05	2.5182e-05	+	0	0	≈	0	0	≈	0	0	≈	0	2.6000e-08	≈	0	0	≈	0	0	
f3	81.1508	44.8551	+	130.1655	61.4148	+	73.2573	49.3131	+	42.7048	37.3117	≈	45.8142	45.0262	≈	6.0790	21.0966	−	47.6559	40.1144	−	28.5127	0	
f4	354.1972	12.1989	+	52.3782	13.5991	+	11.9128	1.4974	+	16.6778	3.0663	+	20.7446	3.6078	+	27.6997	4.3434	+	14.4828	3.2964	+	5.4524	1.7499	
f5	1.0560e-06	3.4705e-06	−	1.0200e-06	2.1667e-06	≈	2.2160e-07	3.6347e-07	−	4.6960e-07	7.1185e-07	−	2.9200e-08	7.6535e-08	−	1.1284e-02	1.0154e-02	+	0	0	−	8.4760e-07	6.9760e-07	
f6	402.8993	13.2481	+	109.0697	18.5324	+	63.9635	1.6528	+	67.0418	3.1429	+	72.2418	3.0433	+	76.3486	6.2520	+	64.2986	2.4945	+	72.4673	31.4814	
f7	356.6496	11.9238	+	48.0256	12.7000	+	11.8030	1.8240	+	17.4339	3.3116	+	19.9789	3.5861	+	27.6979	4.3910	+	13.9689	3.3687	+	5.3330	2.0081	
f8	1.4325e-02	3.3498e-02	+	0	0	≈	0	0	≈	0	0	≈	0	0	≈	0.3244	0.2249	+	0	0	≈	0	0	
f9	1.2895e+04	315.9155	+	5944.3653	675.2434	+	3083.9943	288.0892	+	3157.7247	324.3247	+	3115.4971	365.5107	+	3071.8217	467.5364	+	3125.8444	415.9888	+	344.8417	216.4926	
f10	130.6679	36.9136	+	43.4862	5.9622	+	47.6132	9.5137	+	28.9525	3.1583	+	28.1008	2.3146	+	106.0686	14.2415	+	21.5195	4.2126	+	19.1006	0.7960	
f11	6.3963e+04	4.8924e+04	+	8703.7359	4520.5511	+	2189.6099	461.3564	+	1824.4905	461.1686	+	1802.7792	429.2241	+	2743.0793	2421.5774	+	1688.9272	241.9574	+	77.0034	69.7056	
f12	281.1683	89.6075	+	158.4886	36.5454	+	49.5593	23.1053	+	31.8991	21.5073	+	40.6065	20.4860	+	432.0870	265.5983	+	35.6092	28.0484	+	4.0849	2.3414	
f13	125.2950	9.1703	+	39.2760	4.9553	+	29.5436	2.8117	+	25.3399	2.2669	+	23.8261	1.1891	+	170.8393	14.3801	+	25.7679	2.1453	+	21.8578	0.8697	
f14	109.6400	10.3061	+	43.6299	11.7375	+	40.9693	10.1333	+	24.9593	2.9070	+	21.9799	2.1593	+	333.2286	53.3546	+	23.0711	3.4311	+	17.5995	0.6506	
f15	2294.3239	768.0798	+	469.6316	117.3607	+	421.1741	119.6196	+	411.9340	131.0004	+	466.0163	137.8680	+	375.8249	89.5257	+	220.4684	112.8607	+	124.5750	1.3253	
f16	1134.0312	473.1206	+	398.8502	135.0110	+	237.7848	73.5914	+	264.6026	81.8682	+	277.9023	101.6144	+	409.6369	89.9078	+	164.5395	61.9805	+	95.5854	73.4830	
f17	528.1716	370.1393	+	37.5491	9.1491	+	38.9370	10.9603	+	24.3531	1.9339	+	24.4940	2.0236	+	151.3762	91.6912	+	25.1765	1.7141	+	21.0169	0.2199	
f18	61.0342	11.1425	+	26.9612	3.4182	+	22.3873	4.7890	+	12.7583	1.7861	+	10.3427	1.8853	+	92.8490	22.6882	+	12.3710	1.9261	+	4.1287	0.5933	
f19	843.8771	437.9974	+	187.9146	71.0948	+	151.6024	47.4918	+	155.5696	81.0373	+	110.8397	76.9635	+	114.9480	42.8406	+	82.5268	49.6671	+	26.8822	4.5870	
f20	554.7086	10.9797	+	248.0946	12.7168	+	212.9126	2.2643	+	217.3475	3.0116	+	223.8606	4.3609	+	225.8018	3.0949	+	215.0096	3.9790	+	205.8958	2.2141	
f21	7388.0769	6598.7618	+	100.0000	0	≈	2517.2818	1699.7981	+	1460.2533	1858.3801	+	2799.2419	1422.9480	+	243.8704	714.0639	+	1998.9925	1901.6635	+	100.0000	0	
f22	766.3361	18.9653	+	438.5383	10.1365	+	433.0571	4.4352	+	432.0560	6.6002	+	435.5713	6.2634	+	444.0352	6.9757	+	426.4575	7.8831	+	404.6086	4.9329	
f23	835.3793	14.6299	+	494.7646	6.3696	+	508.5951	2.5936	+	507.0193	4.5214	+	514.2893	5.3806	+	519.8682	9.5723	+	502.2175	4.0548	+	485.0280	4.0001	
f24	499.5745	31.2140	+	531.8495	22.5964	+	481.7015	3.8593	+	482.9205	5.1481	+	481.1687	3.2098	+	526.5783	22.3243	+	481.9139	11.2951	−	480.2326	1.8276e-03	
f25	4076.8170	646.3637	+	1257.0443	84.4990	+	1174.1354	51.2574	+	1151.0770	40.8196	+	1191.5331	53.0547	+	1425.6038	83.4545	+	1109.1792	58.3099	+	555.3640	139.9583	
f26	509.3493	10.9505	+	522.7851	13.8136	+	537.4280	21.6862	+	507.1303	10.9111	+	509.6175	7.4911	+	626.1623	32.1868	+	472.2466	11.4154	+	463.4620	4.9009	
f27	464.8470	16.5881	≈	482.5595	24.6988	+	469.9104	20.1846	+	458.8487	0	≈	458.8487	0	≈	492.3117	13.9791	+	451.7287	0.3012	−	458.8490	0	
f28	572.2938	258.2466	+	533.8714	36.4854	+	354.6931	10.8992	+	363.2761	12.4372	+	356.6651	14.7402	+	386.4152	43.6382	+	282.9886	29.0471	−	303.7494	7.5392	
f29	5.8613e+05	1.5331e+04	+	6.3375e+05	2.5923e+04	+	6.7384e+05	7.6393e+04	+	5.9977e+05	2.5149e+04	+	6.1019e+05	3.1774e+04	+	3.7569e+05	1.2512e+05	−	1588.4159	950.8979	−	5.7952e+05	447.6272	
+ / ≈ / −	27/1/1			26/3/0			25/3/1			23/5/1			23/5/1			25/2/2			20/3/6					

Table S36. Performance comparison of L-SRTDE with other algorithms on 100D. + means that L-SRTDE performs significantly better than a compared algorithm.

Func.	DE		NL-SHADE-LBC		L-SHADE		jSO		jSOa		mLSHADE-RL		RDE		L-SRTDE	
	Mean	Std sig	Mean	Std sig	Mean	Std sig	Mean	Std sig	Mean	Std sig	Mean	Std sig	Mean	Std sig	Mean	Std
f1	6297.5872	7831.9493 +	3789.3834	1978.4547 +	0	0 −	0	0 −	0	0 −	6.0580e-06	1.9013e-05 −	0	0 −	266.2949	950.0397
f2	3.1040e+05	2.4113e+04 +	2.4705	1.3065 +	8.7932e-06	7.6439e-06 −	1.8924e-06	1.7066e-06 −	0	0 −	1.2748e-06	1.0005e-06 −	8.8992e-06	8.7904e-06 −	2.6219e-03	1.9758e-03
f3	209.5581	35.0422 ≈	214.5650	32.5433 +	197.8145	5.6944 ≈	192.1875	22.7492 ≈	198.7932	9.1992 ≈	16.9015	47.7588 −	141.4785	69.8658 −	198.8534	9.1726
f4	810.3526	22.6946 +	112.6124	26.1156 +	35.3124	5.4375 +	42.1795	6.0242 +	46.9145	5.9748 +	75.4577	15.4049 +	37.7952	8.6644 +	17.1531	3.3159
f5	5.6554e-04	9.1440e-04 +	1.5557e-03	2.5687e-03 +	5.5580e-03	4.1868e-03 +	4.6008e-04	8.2696e-04 ≈	2.2232e-06	2.0497e-06 −	0.7829	0.2771 +	6.9621e-04	1.5476e-03 −	4.0989e-05	1.4181e-05
f6	928.8761	23.6022 +	257.7910	38.2710 +	141.5592	5.0275 +	148.2234	8.7664 +	147.7772	7.5476 +	157.4696	11.2971 +	165.9225	11.3690 +	129.5865	52.7233
f7	820.0319	17.8679 +	125.5560	36.0287 +	34.2679	6.3971 +	42.6103	6.2833 +	44.8855	10.1115 +	78.0445	11.6990 +	40.5163	9.3113 +	16.2775	3.4572
f8	5.1992	4.5353 +	0.3229	0.5661 +	0.3580	0.3436 +	7.6006e-02	0.1628 +	0	0 ≈	66.7444	28.0271 +	0	0 ≈	0	0
f9	2.9428e+04	445.1559 +	1.5017e+04	1211.8675 +	1.0360e+04	489.7228 +	9682.9285	559.0376 +	9646.9133	667.8245 +	9269.8036	1207.0450 +	1.0705e+04	1040.2117 +	1755.8422	690.3930
f10	594.3109	47.1077 +	359.9170	75.0328 +	443.5645	100.5577 +	110.4749	35.1581 +	96.6443	38.7642 +	737.8702	83.3021 +	127.4252	32.5415 +	19.4251	3.8357
f11	2.3340e+05	6.5851e+04 +	1.4960e+05	4.6247e+04 +	2.5826e+04	1.1572e+04 +	1.7567e+04	8198.7151 +	1.3590e+04	3958.2689 +	4057.4105	598.5864 +	1.4985e+04	5519.3048 +	2955.2249	2538.5782
f12	2991.2022	2776.1175 +	2574.2139	686.0129 +	442.3133	177.3013 +	153.5380	32.9257 +	221.2587	60.4076 +	1768.2933	835.0585 +	120.3482	28.7880 +	55.1004	22.5514
f13	8384.7757	5890.2600 +	200.0500	23.1853 +	254.2917	27.5606 +	61.7553	12.4284 +	56.7635	8.4486 +	297.4441	43.4561 +	68.8728	12.4394 +	26.9336	1.9445
f14	1751.4844	2841.7035 +	252.5833	44.6028 +	245.8834	45.5826 +	158.0054	33.8829 +	175.1721	50.8155 +	236.0416	42.4894 +	199.1481	40.7206 +	70.5866	26.1500
f15	7583.3327	223.0941 +	1744.2329	485.1380 +	1714.4103	349.2996 +	1770.3289	326.2236 +	1798.1378	317.5488 +	763.7935	258.3543 +	1489.4465	310.7188 +	107.6484	68.6527
f16	4480.2291	576.2551 +	1401.3738	288.0038 +	1155.2812	199.7139 +	1319.4011	196.5215 +	1271.3905	211.5288 +	1109.9621	216.9268 +	975.5584	204.7189 +	77.1003	55.3846
f17	1.1745e+05	4.4592e+04 +	231.3133	47.4005 +	231.5409	76.4706 +	180.8979	42.8708 +	159.4237	37.2490 +	255.4421	75.8978 +	217.3814	39.0105 +	26.1629	1.8952
f18	2110.0363	2409.4343 +	161.0154	17.8223 +	183.7904	28.1862 +	101.1701	17.9910 +	83.1063	14.3667 +	172.0926	26.1405 +	123.4720	20.3652 +	14.8924	2.0106
f19	4553.5300	218.6408 +	1730.8748	273.3240 +	1537.8810	145.7492 +	1368.5323	242.2703 +	1313.0477	223.5937 +	1030.6390	165.4642 +	1176.3211	216.3574 +	166.4518	6.6191
f20	1042.7436	19.3117 +	303.2746	21.2003 +	260.3477	5.2174 +	263.7504	6.5101 +	268.3065	8.6708 +	297.8885	11.0861 +	258.4600	6.9538 +	235.1817	2.7393
f21	3.0203e+04	605.8924 +	100.2357	0.8135 −	1.1302e+04	533.0979 +	1.0547e+04	818.2048 +	1.0309e+04	812.3695 +	9842.5794	1040.0384 +	1.1275e+04	617.6968 +	2333.5140	898.1361
f22	722.0095	244.3876 +	602.1453	12.7493 +	567.2957	11.0164 +	565.5059	12.3325 +	556.7488	7.7295 +	677.0772	18.5202 +	563.0788	10.2459 +	539.6581	8.7249
f23	1454.4970	301.6624 +	866.7395	22.9737 +	917.0408	7.4563 +	901.5313	9.7192 +	911.4239	9.0714 +	1054.1494	32.1020 +	890.7376	10.4892 +	813.3810	13.8438
f24	734.3601	47.1616 +	790.6450	46.9775 +	748.1654	32.9379 +	724.3528	42.8851 +	730.7854	33.0592 +	731.1289	51.0382 +	722.0891	30.9434 +	639.1328	26.0012
f25	4799.6004	2637.6651 +	3366.0191	105.7495 +	3404.1985	91.1360 +	3224.9706	90.0328 +	3274.1567	99.8291 +	5111.0151	343.0884 +	3153.6880	96.4969 +	2156.0820	144.9626
f26	594.9174	16.9963 +	631.9551	12.5131 +	642.8834	16.5419 +	579.3070	26.2424 +	582.3296	15.1161 +	885.8019	41.2662 +	500.0226	5.0000e-04 −	519.3510	12.0397
f27	558.0172	27.5655 +	590.0760	19.9774 +	520.6894	19.7827 +	519.6381	24.6112 +	528.1392	33.1653 +	488.0857	98.8912 +	500.0222	5.5377e-04 ≈	500.3146	13.7598
f28	4470.9011	1180.9155 +	1590.7621	224.1107 +	1272.2918	189.8095 +	1248.7132	221.5815 +	1346.2813	201.0848 +	1496.4028	265.0428 +	836.3172	179.5924 +	702.8170	33.8451
f29	3949.8511	1967.5551 +	2729.2891	207.6445 +	2340.6329	141.2308 +	2333.5068	142.3203 +	2456.5301	184.3797 +	2455.3722	270.9049 +	1005.7470	192.5951 −	2063.6468	17.8164
+ / ≈ / −	28/1/0		28/0/1		26/1/2		25/2/2		24/2/3		26/0/3		21/2/6			

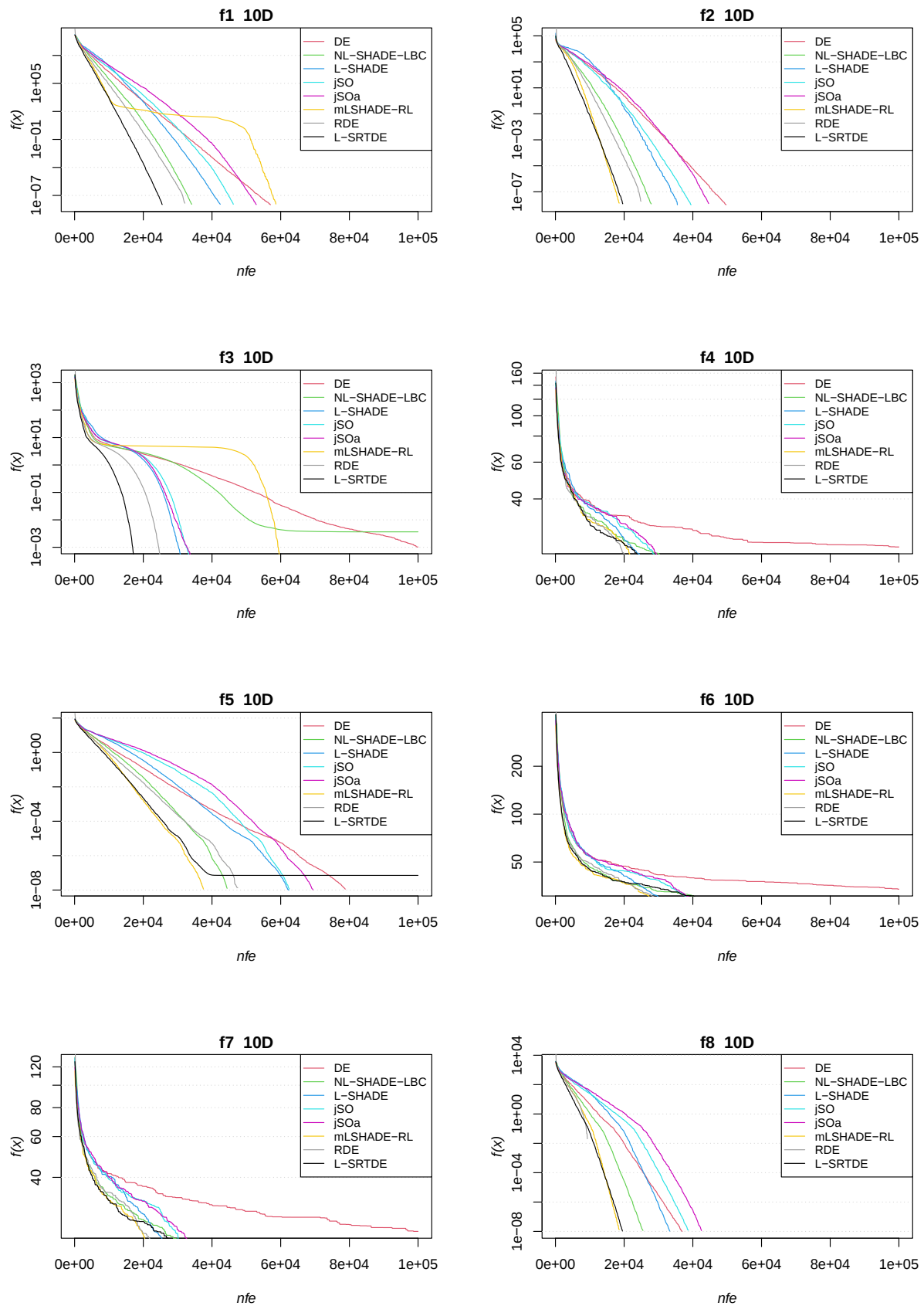


Figure S1. Convergence graphs of algorithms for functions f1 to f8 in 10D.

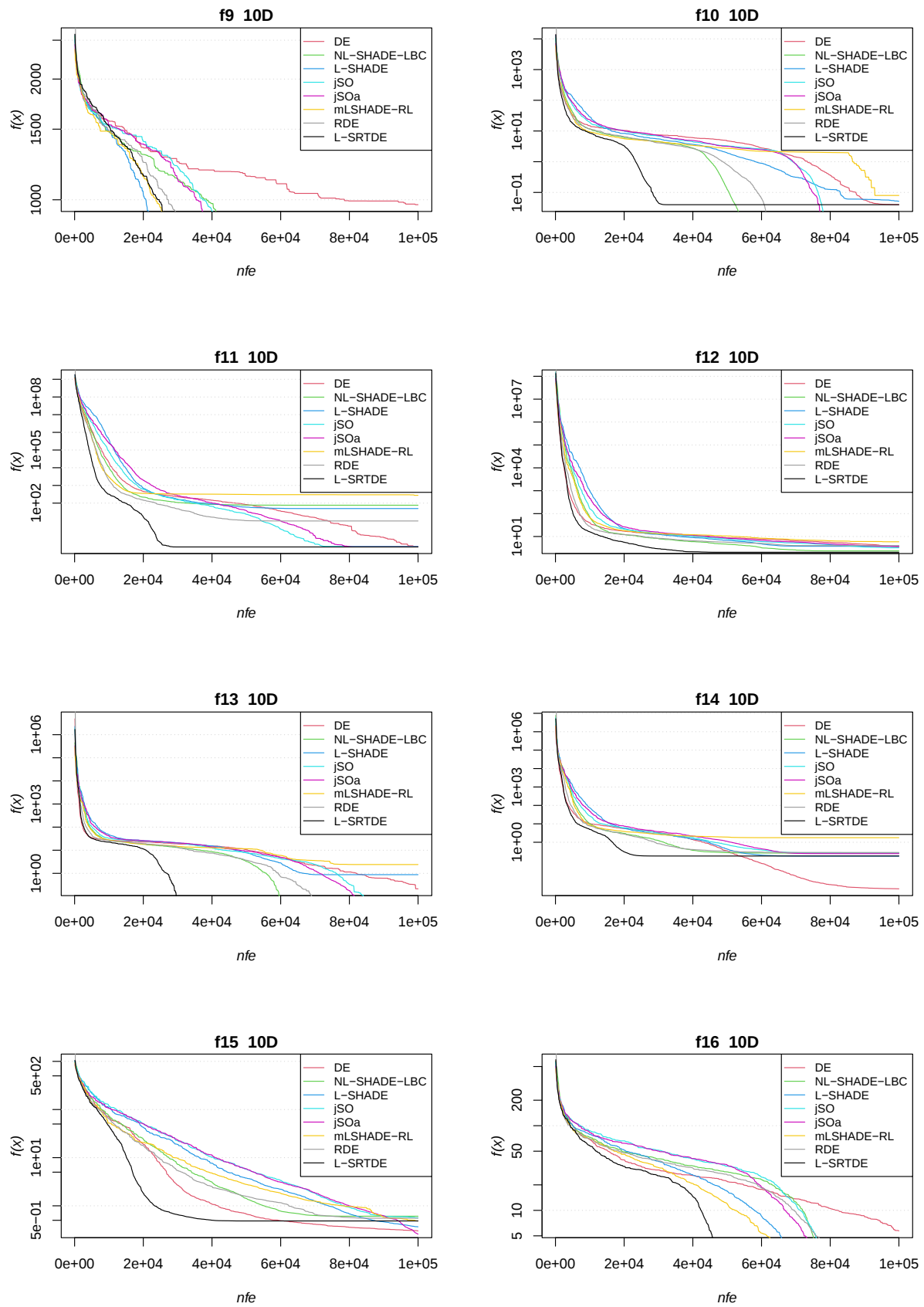


Figure S2. Convergence graphs of algorithms for functions f9 to f16 in 10D.

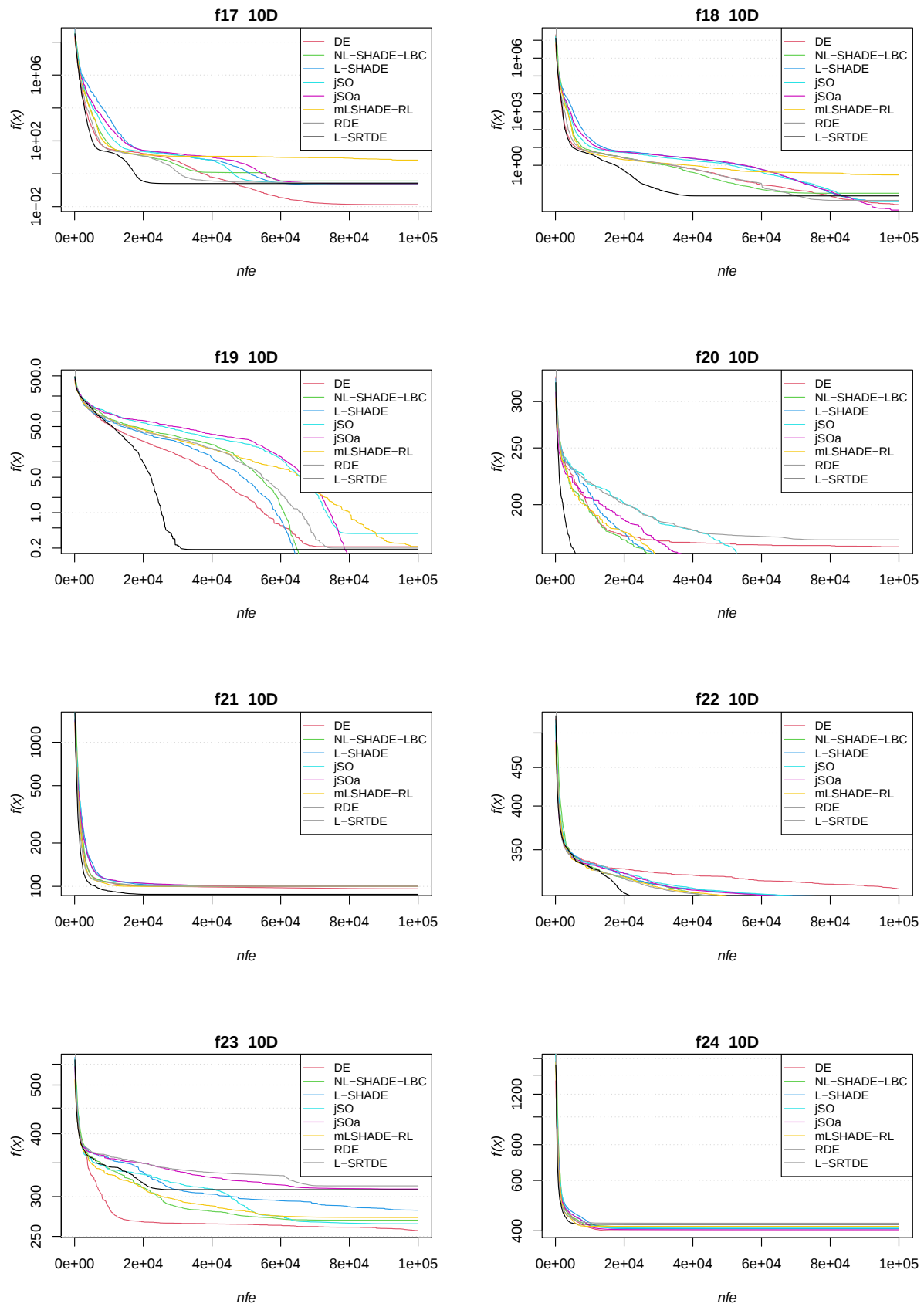


Figure S3. Convergence graphs of algorithms for functions f17 to f24 in 10D.

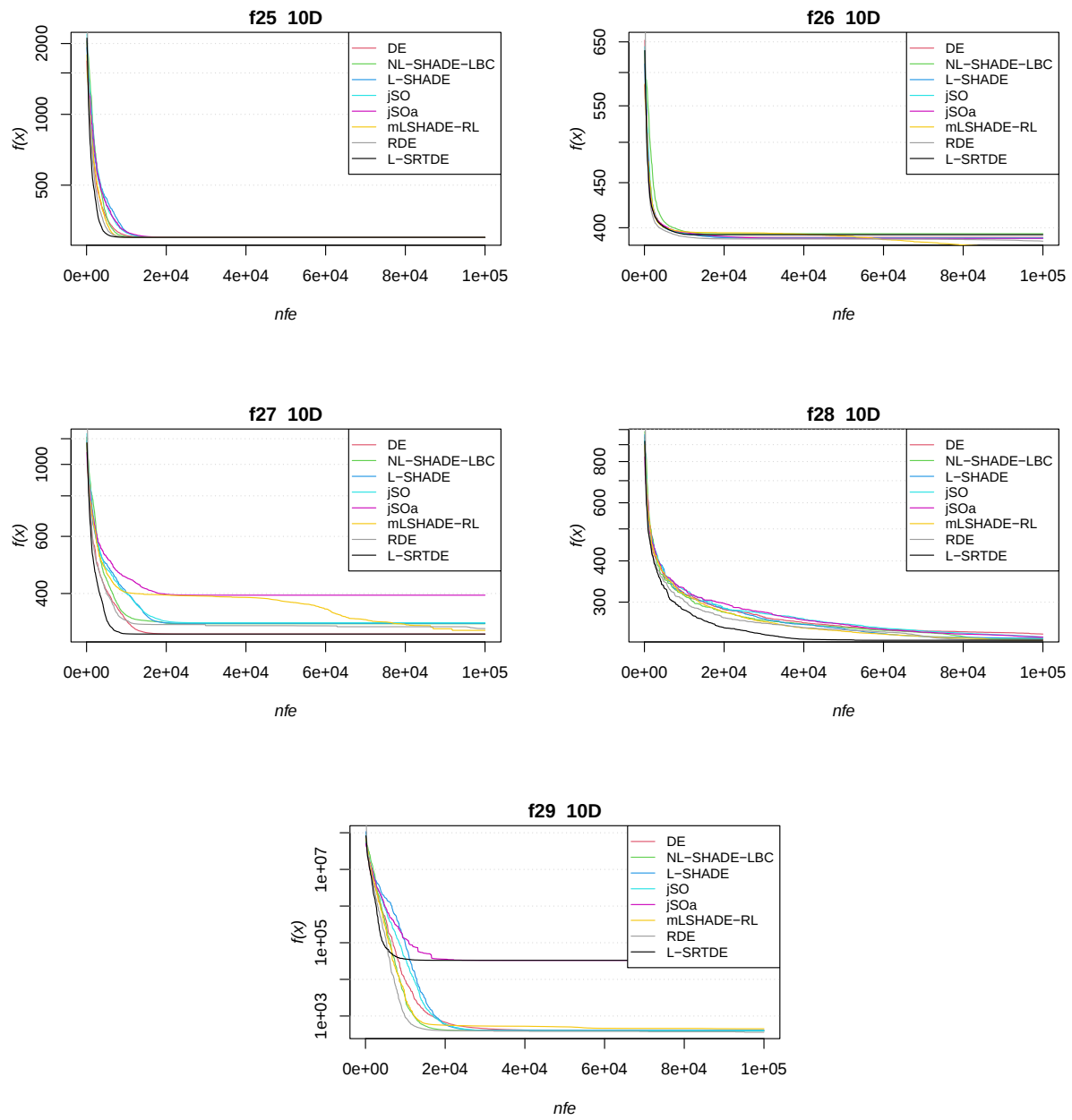


Figure S4. Convergence graph of algorithms for functions f25 to f29 in 10D.

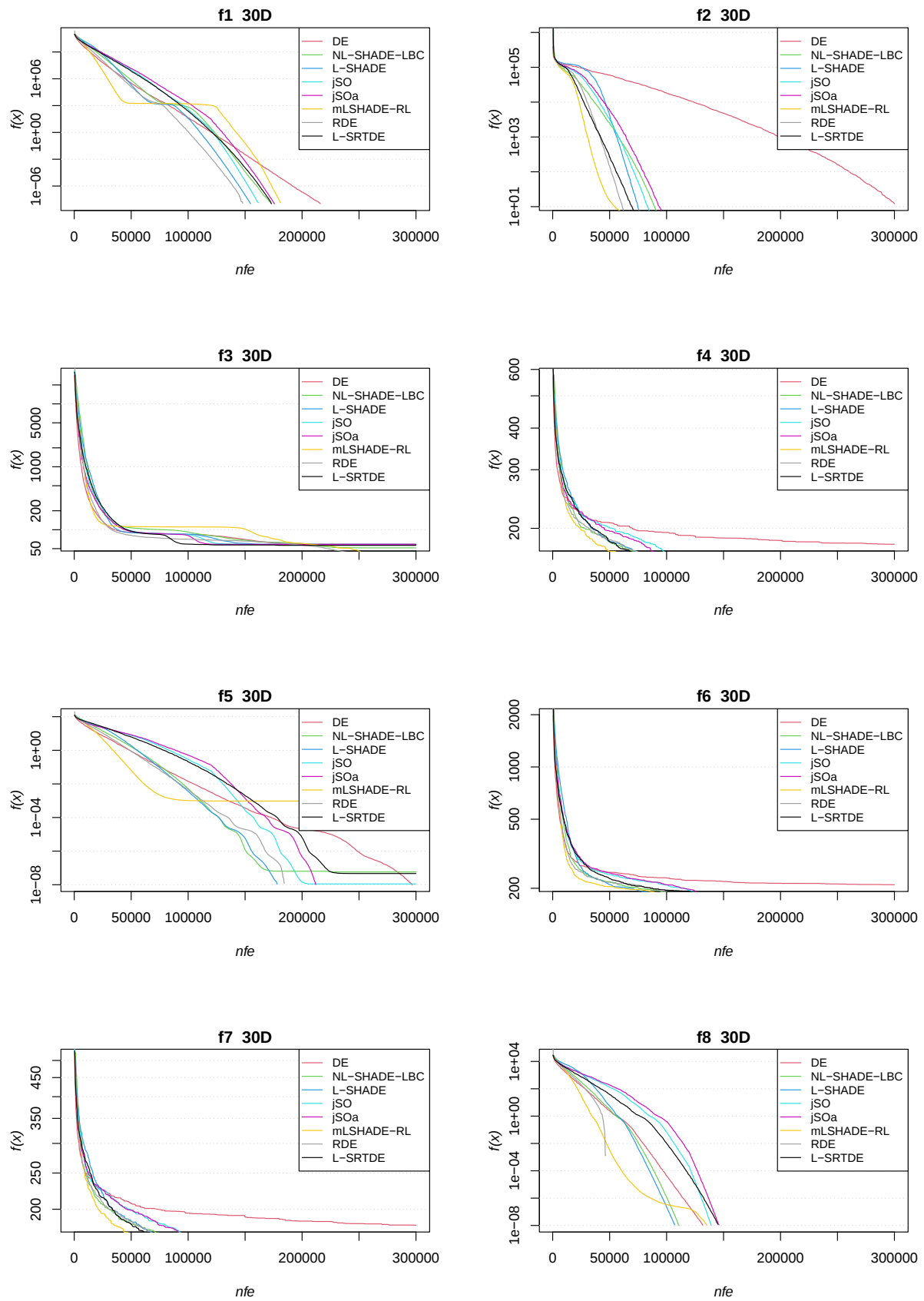


Figure S5. Convergence graphs of algorithms for functions f1 to f8 in 30D.

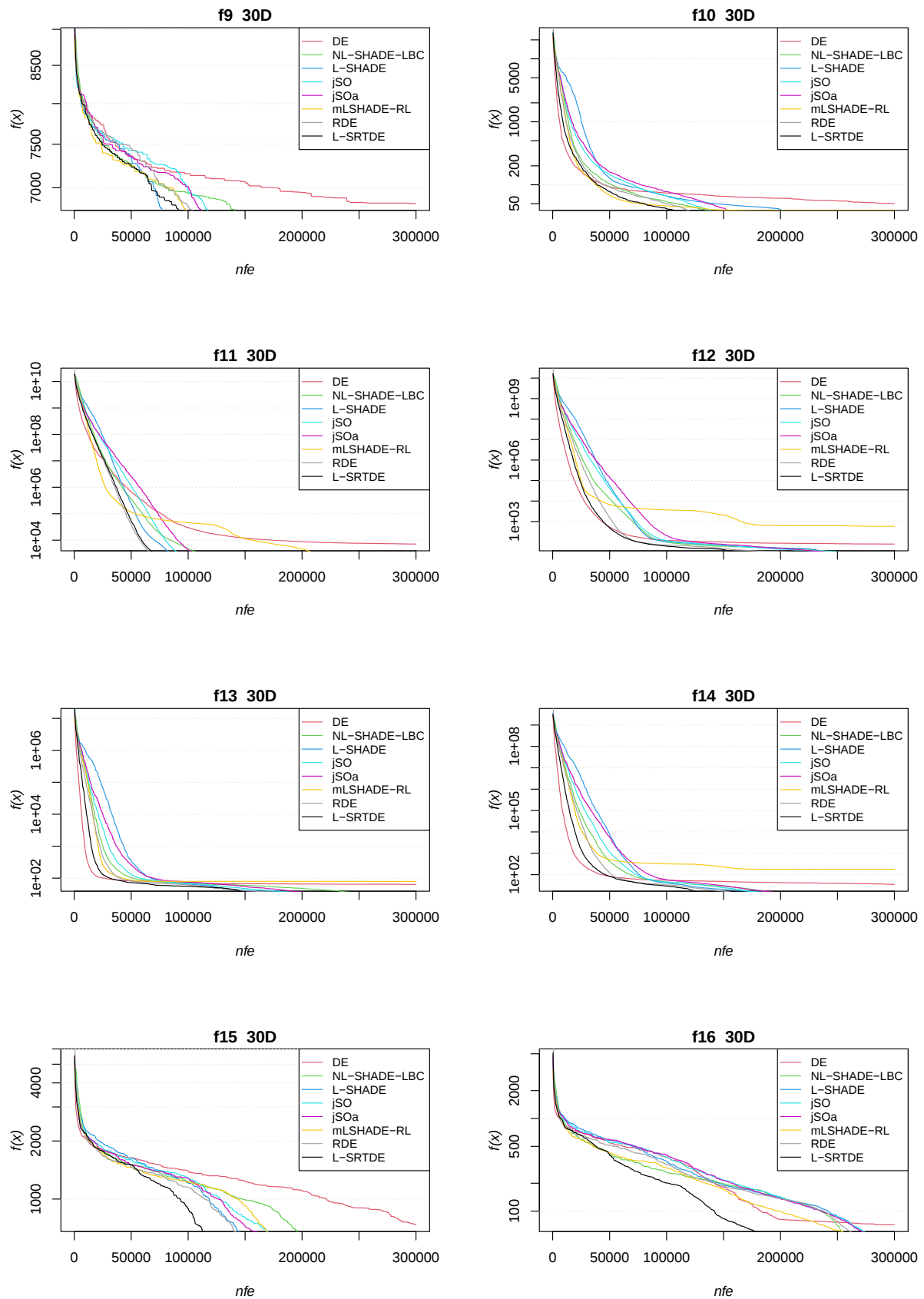


Figure S6. Convergence graphs of algorithms for functions f9 to f16 in 30D.

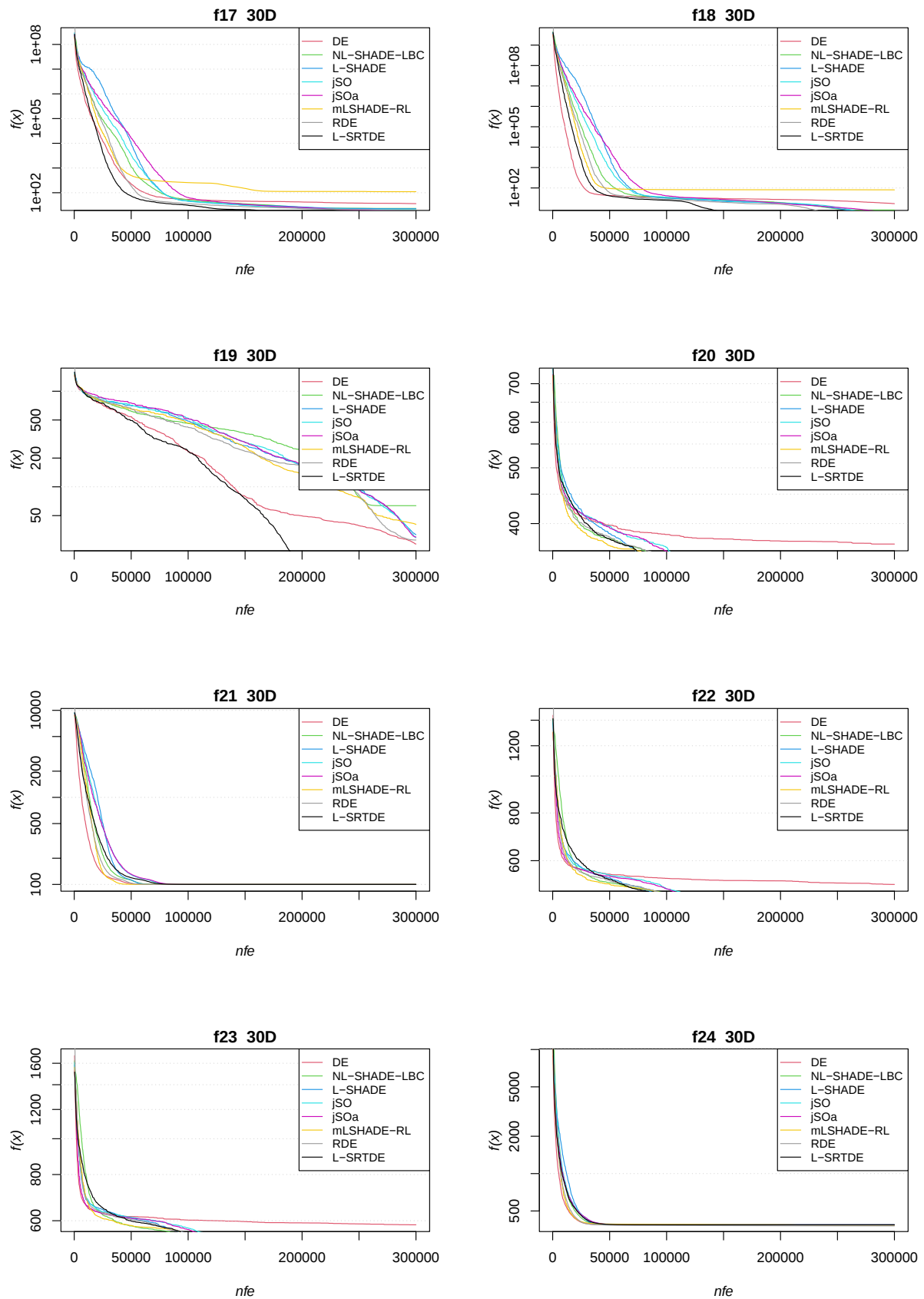


Figure S7. Convergence graphs of algorithms for functions f17 to f24 in 30D.

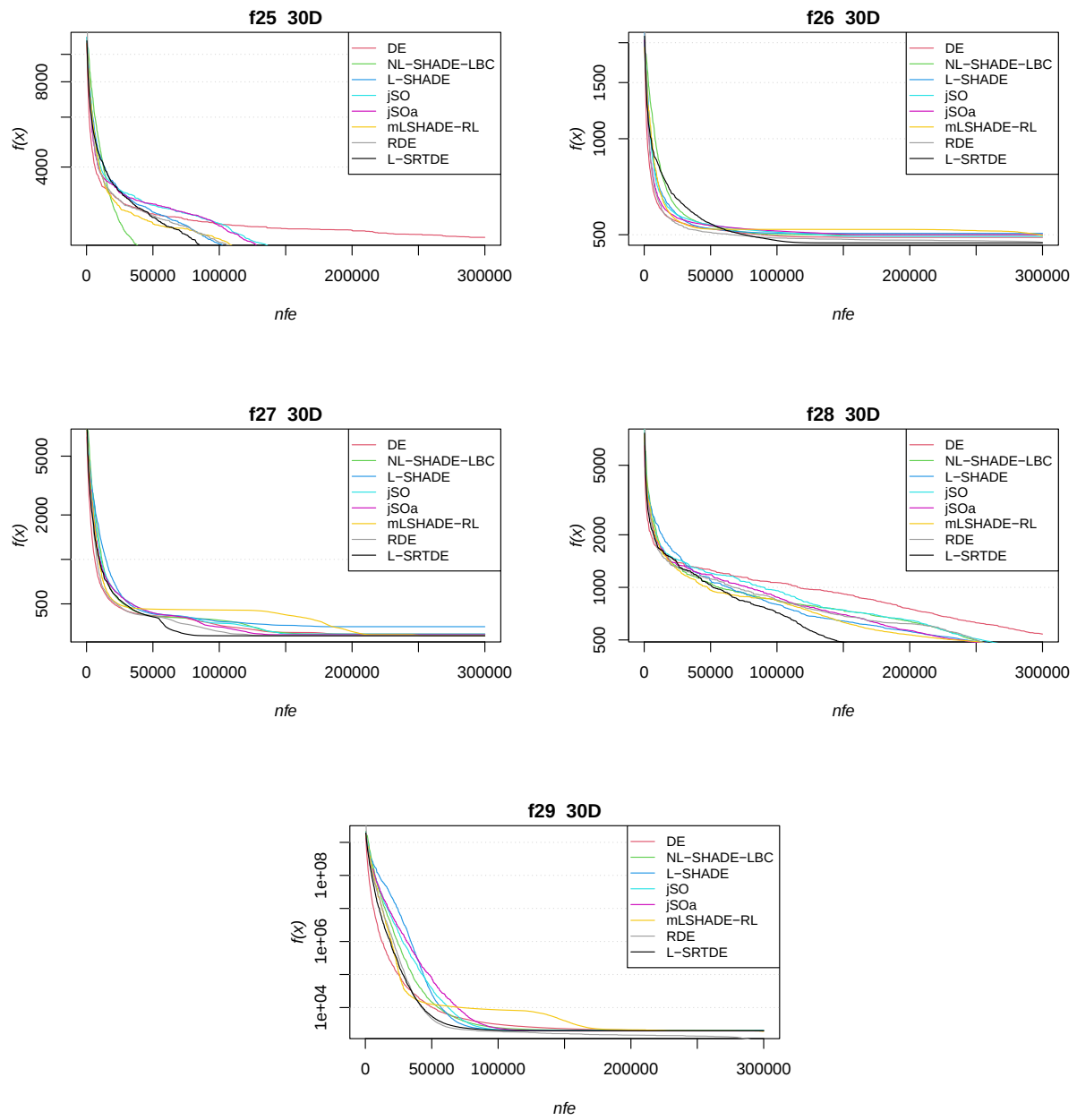


Figure S8. Convergence graph of algorithms for functions f25 to f29 in 30D.

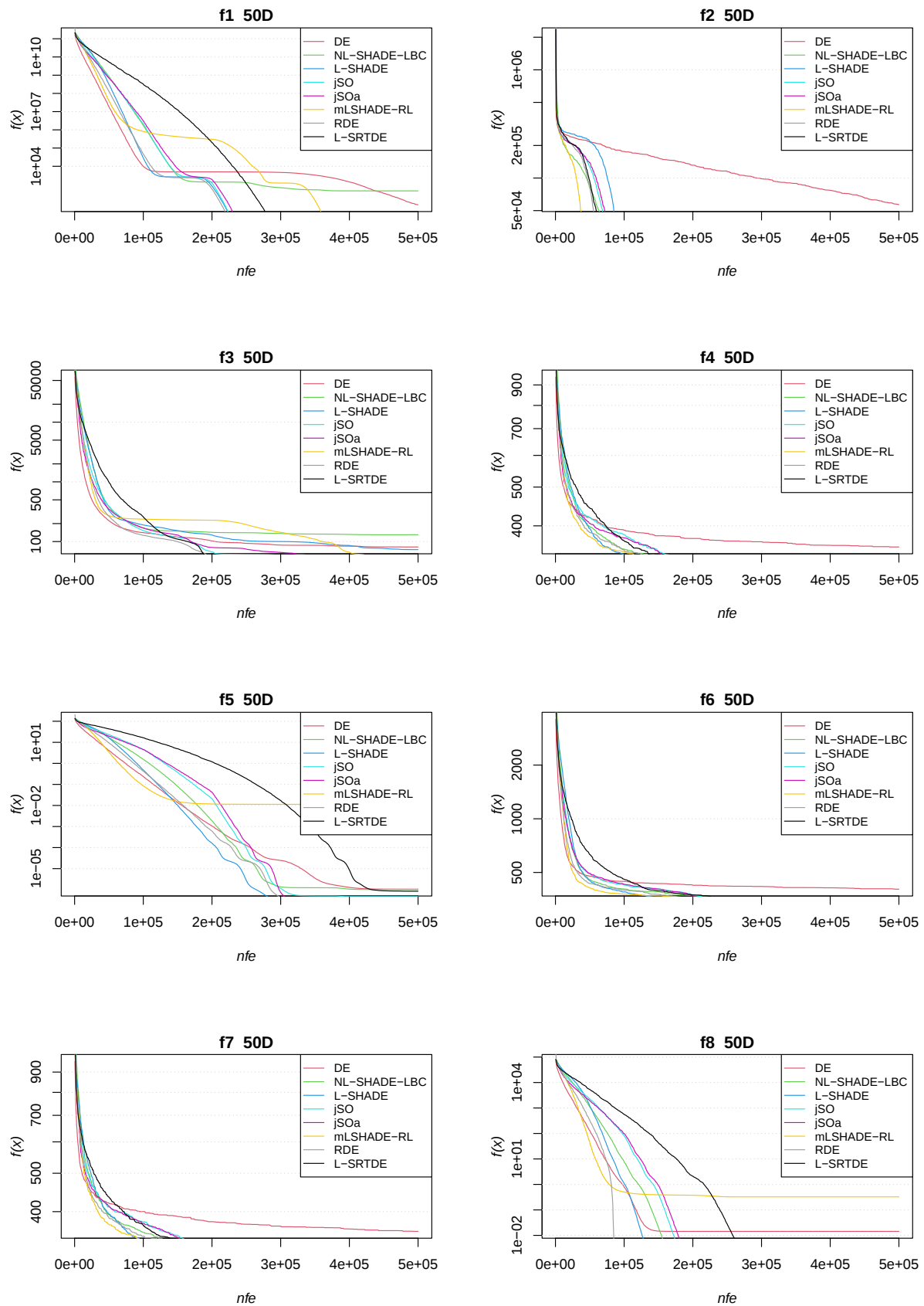


Figure S9. Convergence graphs of algorithms for functions f1 to f8 in 50D.

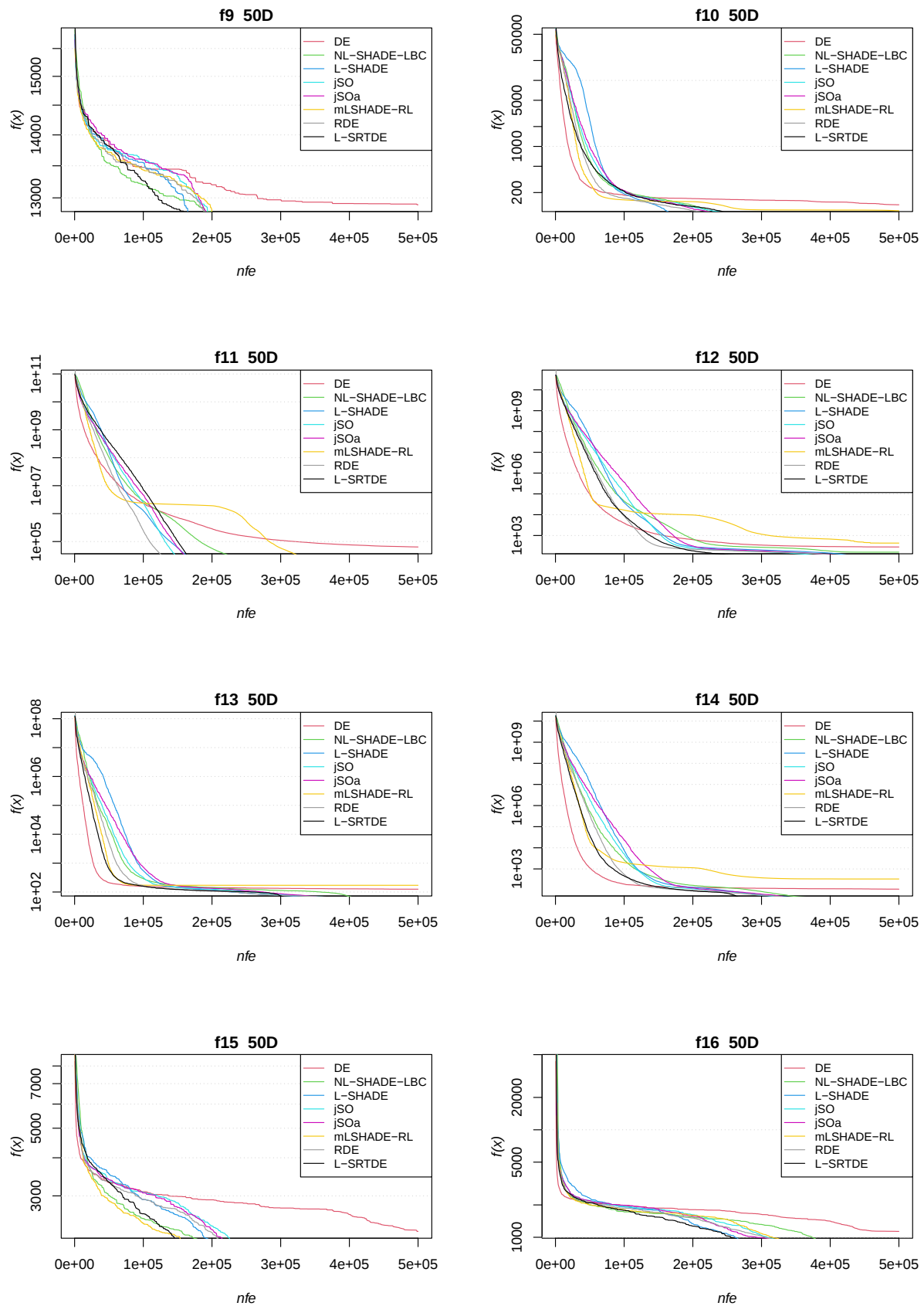


Figure S10. Convergence graphs of algorithms for functions f9 to f16 in 50D.

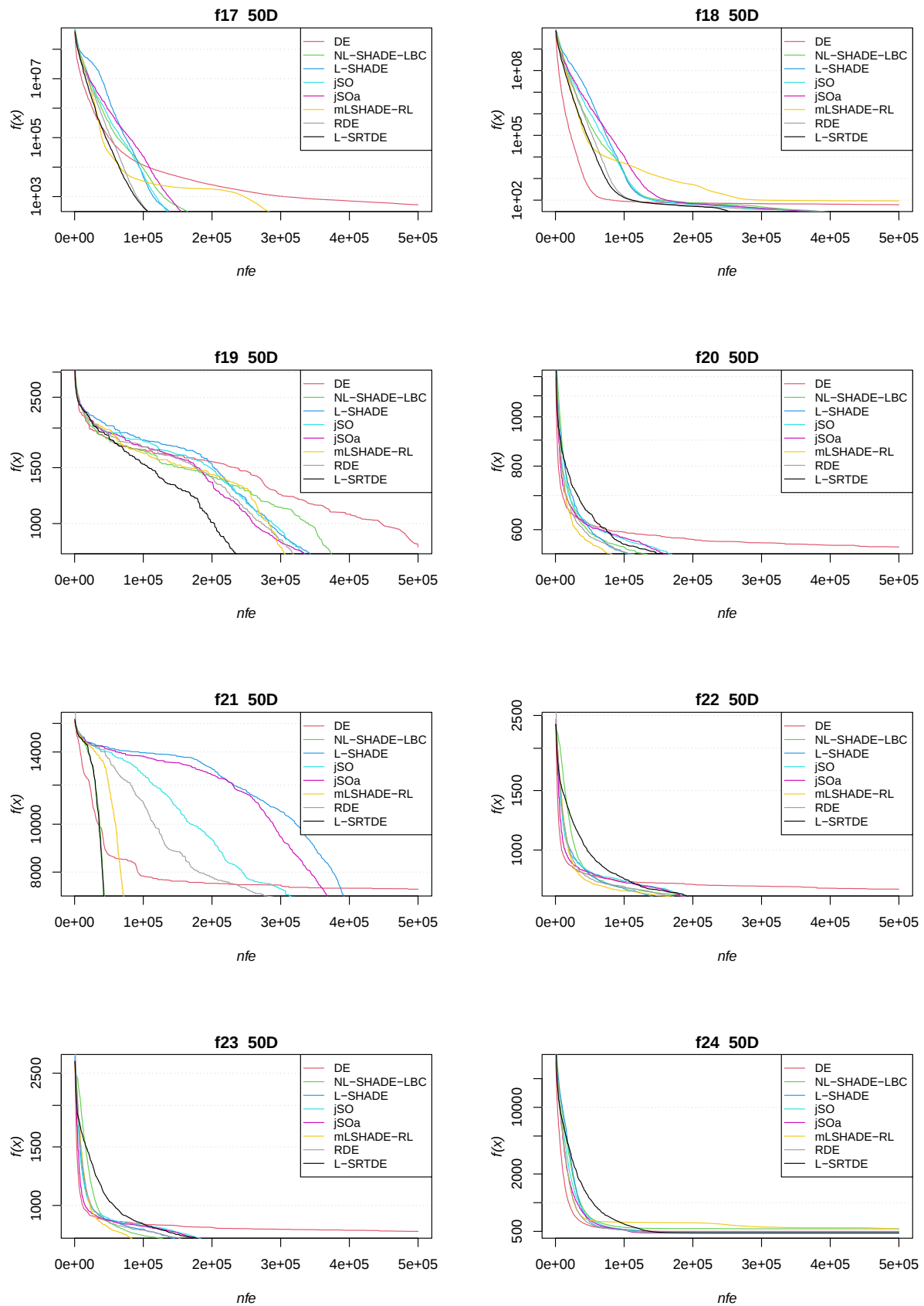


Figure S11. Convergence graphs of algorithms for functions f17 to f24 in 50D.

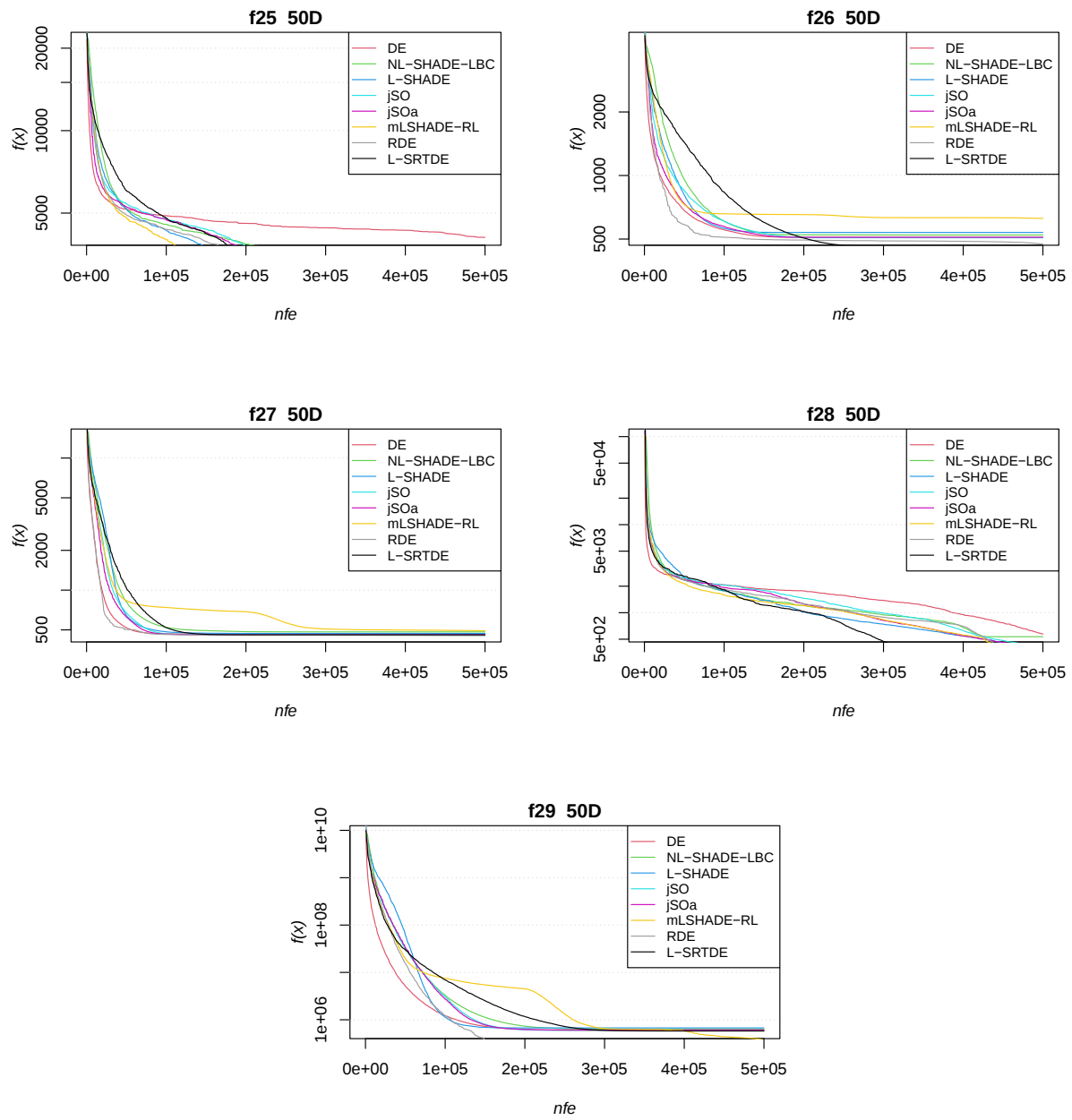


Figure S12. Convergence graph of algorithms for functions f25 to f29 in 50D.

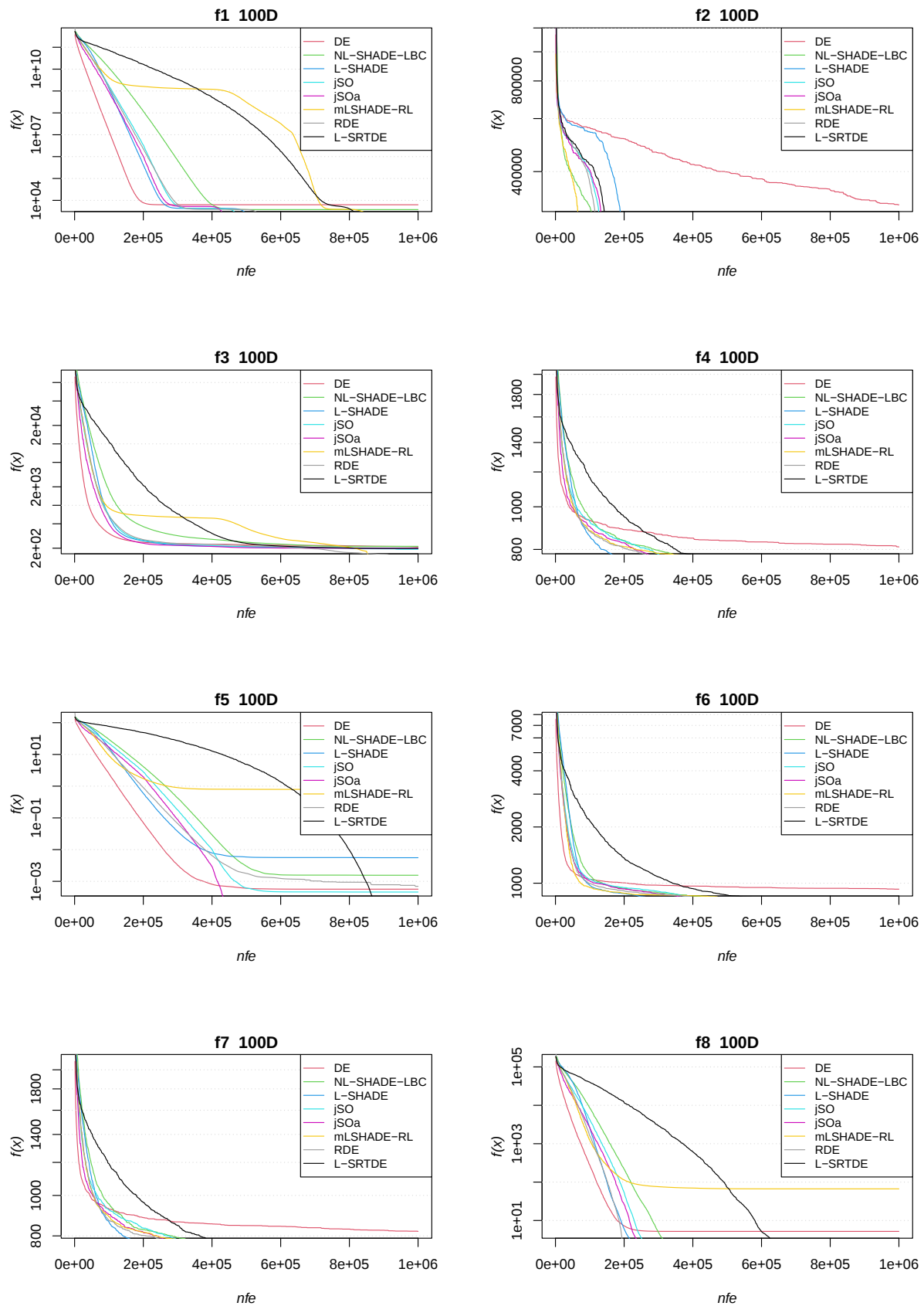


Figure S13. Convergence graphs of algorithms for functions f1 to f8 in 100D.

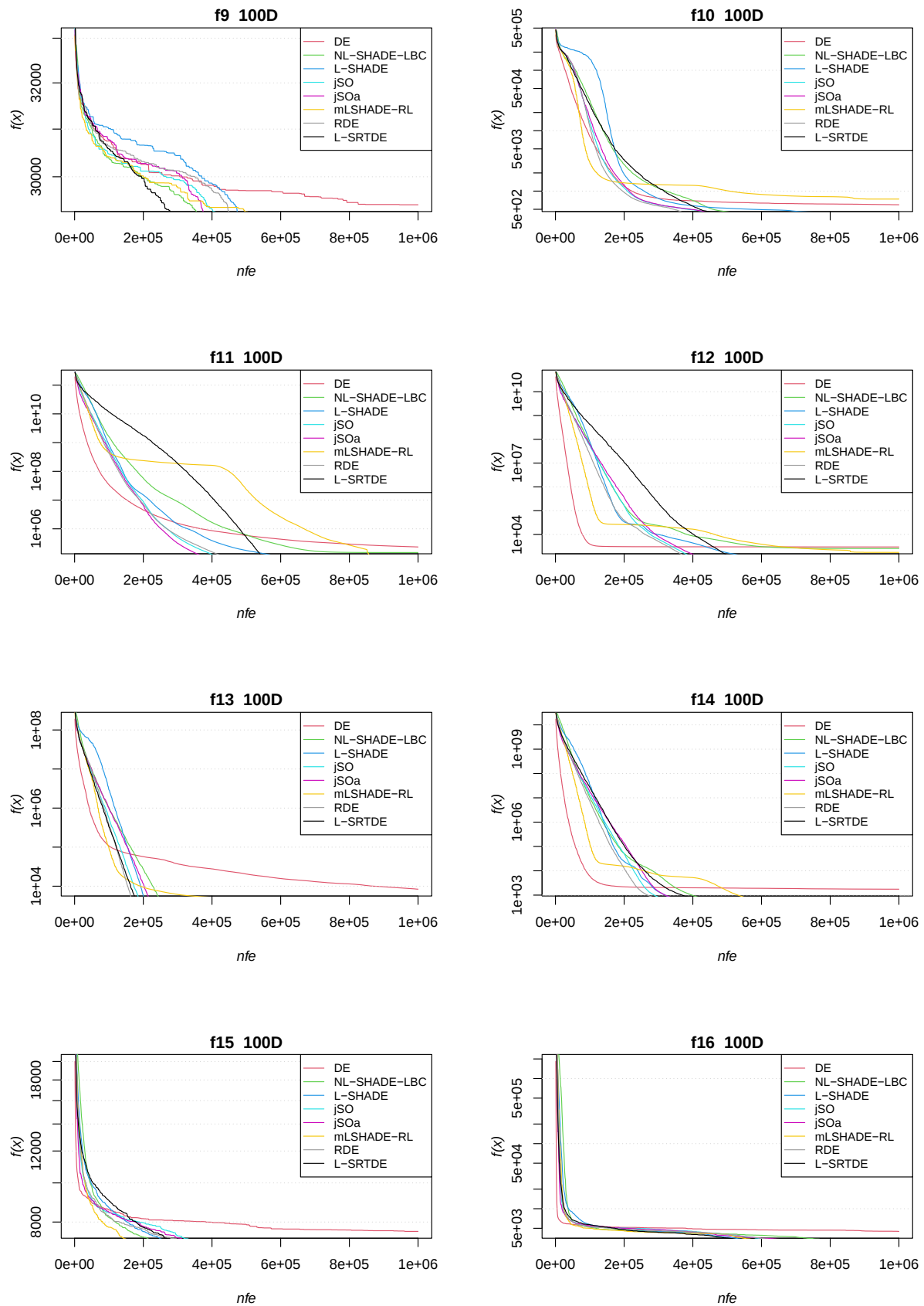


Figure S14. Convergence graphs of algorithms for functions f9 to f16 in 100D.

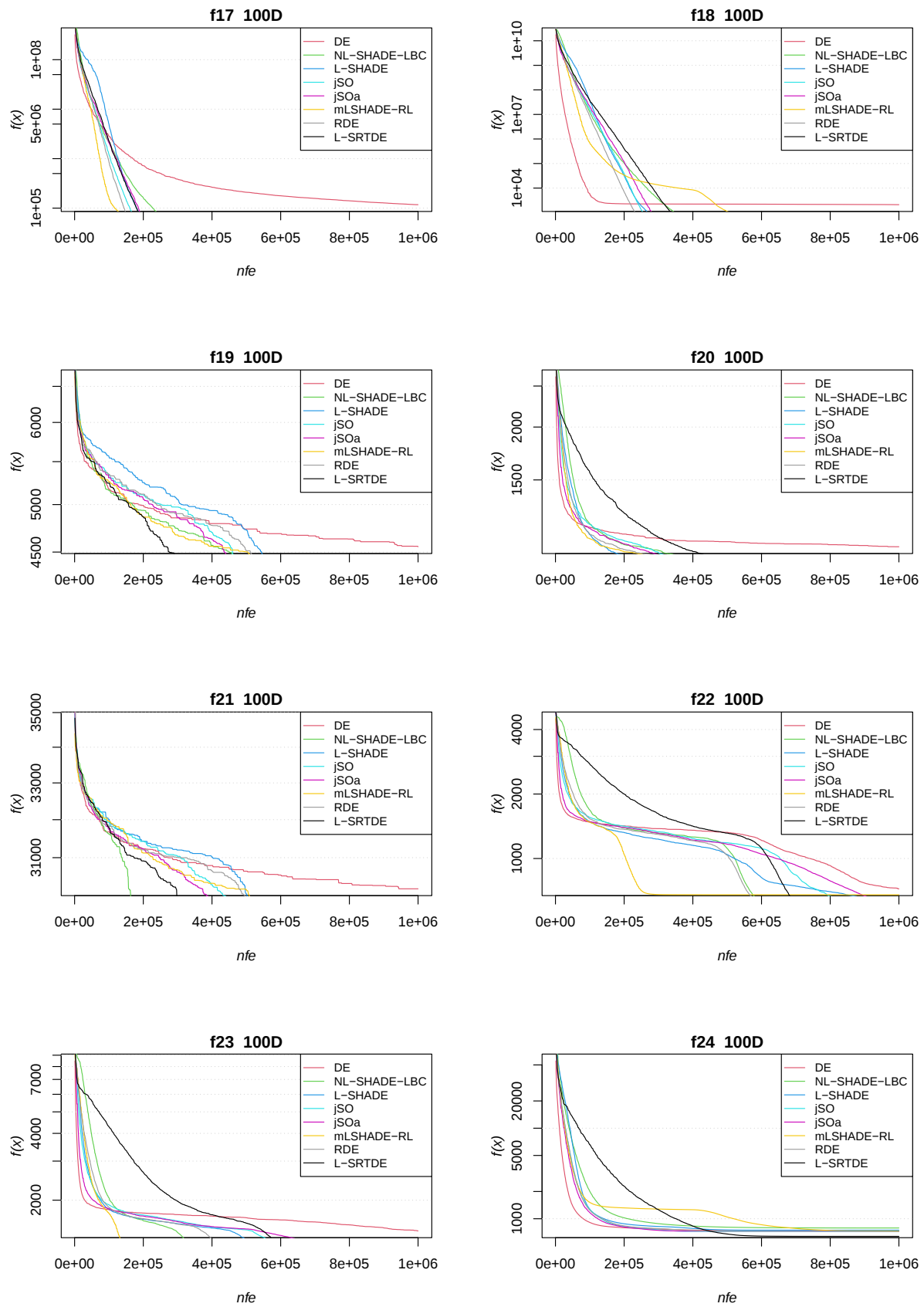


Figure S15. Convergence graphs of algorithms for functions f17 to f24 in 100D.

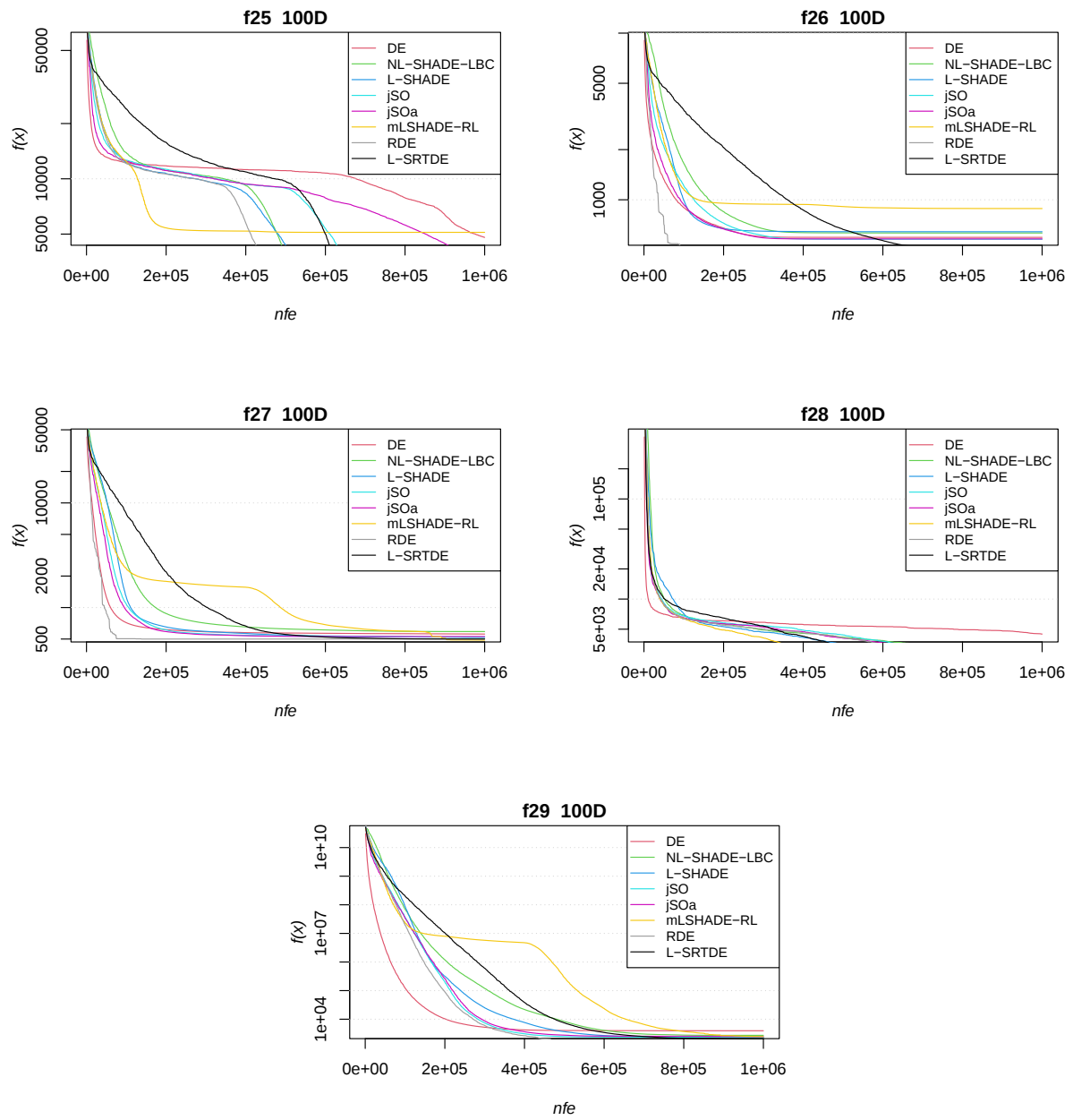


Figure S16. Convergence graph of algorithms for functions f25 to f29 in 100D.