Supplemental Material for "Adaptive Multimodal Continuous Ant Colony Optimization"

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TABLE SI
THE BASIC PROPERTIES OF CEC'2013 MULTIMODAL PROBLEMS

F	Name	D	No. of global optima	No. of local optima
F_1	Five-Uneven-Peak Trap	1	2	3
F_2	Equal Maxima	1	5	0
F_3	Uneven Decreasing Maxima	1	1	4
F_4	Himmelblau	2	4	0
F_5	Six-Hump Camel Back	2	2	2
F_6	Shubert with 2D	2	18	many
F_7	Vincent with 2D	2	36	0
F_8	Shubert with 3D	3	81	many
F_9	Vincent with 3D	3	216	0
F_{10}	Modified Rastrigin	2	12	0
F_{11}	Composition Function 1 with 2D	2	6	many
F_{12}	Composition Function 2 with 2D	2	8	many
F_{13}	Composition Function 3 with 2D	2	6	many
F_{14}	Composition Function 3 with 3D	3	6	many
F_{15}	Composition Function 4 with 3D	3	8	many
F_{16}	Composition Function 3 with 5D	5	6	many
F_{17}	Composition Function 4 with 5D	5	8	many
F_{18}	Composition Function 3 with 10D	10	6	many
F_{19}	Composition Function 4 with 10D	10	8	many
F_{20}	Composition Function 4 with 20D	20	8	many

TABLE SII
DEFAULT PARAMETER SETTING FOR LAM-ACOS

Parameter	***G***	δ	N
Value	[2, 20]	1.0E-04	2

TABLE SIII
EXPERIMENTAL RESULTS OF LAM-ACOS WITH DIFFERENT SETTINGS FOR THE NICHE SIZE SET ***G*** REGARDING PR AT ACCURACY LEVEL ε=1.0E-04.

F	1.0E-04																	
	LAMC-ACO									LAMS-ACO								
	[2,5]	[2,10]	[2,20]	[2,30]	[5,10]	[5,20]	[5,30]	[10,20]	[10,30]	[2,5]	[2,10]	[2,20]	[2,30]	[5,10]	[5,20]	[5,30]	[10,20]	[10,30]
F_1	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**
F_2	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**
F_3	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**
F_4	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**
F_5	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**
F_6	**1.000**	0.999	0.999	0.978	0.989	0.939	0.878	0.766	0.699	0.985	**0.992**	0.990	0.973	0.941	0.906	0.849	0.690	0.635
F_7	0.739	0.709	**0.743**	0.702	0.682	0.636	0.630	0.615	0.575	**0.687**	0.680	0.683	0.626	0.588	0.577	0.548	0.515	0.518
F_8	**0.796**	0.708	0.639	0.436	0.556	0.418	0.355	0.347	0.290	**0.789**	0.771	0.765	0.577	0.569	0.467	0.395	0.311	0.272
F_9	**0.315**	0.290	0.290	0.249	0.240	0.213	0.196	0.188	0.171	**0.268**	0.257	0.254	0.221	0.202	0.183	0.170	0.156	0.148
F_{10}	**1.000**	**1.000**	**1.000**	0.998	0.998	0.998	0.995	0.987	0.977	0.998	**1.000**	**1.000**	0.997	0.998	0.985	0.980	0.905	0.935
F_{11}	**0.951**	0.719	0.670	0.667	0.670	0.667	0.667	0.667	0.667	**0.997**	0.987	0.961	0.830	0.850	0.791	0.703	0.670	0.667
F_{12}	**0.980**	0.860	0.770	0.748	0.760	0.750	0.740	0.750	0.723	0.985	0.980	0.983	0.973	**0.990**	0.953	0.875	0.831	0.804
F_{13}	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.699**	0.693	0.670	0.667	0.667	0.667	0.667	0.667	0.667
F_{14}	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**
F_{15}	0.691	0.725	0.740	0.745	0.748	**0.750**	0.745	**0.750**	0.745	0.711	0.743	0.748	**0.750**	0.743	**0.750**	0.745	0.748	0.748
F_{16}	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**
F_{17}	0.554	0.600	0.608	0.625	0.608	**0.652**	0.600	0.625	0.593	0.586	0.659	0.708	**0.725**	0.676	0.713	0.703	0.721	0.716
F_{18}	**0.667**	**0.667**	**0.667**	0.660	**0.667**	**0.667**	0.660	**0.667**	0.634	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	0.663	**0.667**	**0.667**	0.660
F_{19}	**0.505**	0.500	0.500	0.493	0.498	0.493	0.453	0.475	0.441	**0.510**	0.502	0.502	0.500	0.502	0.500	0.500	0.502	0.490
F_{20}	**0.331**	0.301	0.267	0.245	0.282	0.248	0.238	0.238	0.208	0.311	0.341	**0.346**	0.328	0.336	0.331	0.314	0.267	0.287

TABLE SIV
EXPERIMENTAL RESULTS OF LAM-ACOS WITH DIFFERENT SETTINGS FOR THE STANDARD DEVIATION δ IN THE LOCAL SEARCH REGARDING PR AT ACCURACY LEVEL ε=1.0E-04.

	1.0E-04									
F	LAMC-ACO					LAMS-ACO				
	1.0E-01	1.0E-02	1.0E-03	1.0E-04	1.0E-05	1.0E-01	1.0E-02	1.0E-03	1.0E-04	1.0E-05
F_1	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**
F_2	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**
F_3	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**
F_4	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**
F_5	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**
F_6	0.072	0.380	**1.000**	0.999	0.791	0.919	0.944	**0.995**	0.990	0.966
F_7	0.688	0.763	**0.795**	0.743	0.699	0.654	**0.726**	0.724	0.683	0.649
F_8	0.000	0.000	0.033	**0.639**	0.171	0.213	0.248	0.411	**0.765**	0.567
F_9	0.264	0.330	**0.333**	0.290	0.266	0.243	**0.303**	0.291	0.254	0.235
F_{10}	0.997	**1.000**	**1.000**	**1.000**	**1.000**	0.995	0.990	0.998	**1.000**	**1.000**
F_{11}	**0.676**	0.670	0.673	0.670	0.667	0.941	0.954	**0.961**	**0.961**	0.951
F_{12}	0.392	0.444	0.708	**0.770**	0.662	0.909	0.924	0.966	**0.983**	0.941
F_{13}	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	0.667	**0.676**	**0.676**	0.670	0.670
F_{14}	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**
F_{15}	0.424	0.400	0.527	**0.740**	0.723	0.699	0.667	0.721	**0.748**	0.745
F_{16}	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**
F_{17}	0.311	0.353	0.456	**0.608**	0.480	0.495	0.488	0.578	**0.708**	0.674
F_{18}	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**
F_{19}	0.480	0.483	0.495	**0.500**	0.493	0.495	0.495	0.498	**0.502**	**0.502**
F_{20}	0.245	0.243	0.262	**0.267**	0.252	0.336	0.319	0.336	**0.346**	0.314

TABLE SV
EXPERIMENTAL RESULTS OF LAM-ACOS WITH DIFFERENT SETTINGS FOR THE NUMBER OF SAMPLED POINTS IN THE LOCAL SEARCH REGARDING PR AT ACCURACY LEVEL ε=1.0E-04.

	1.0E-04													
F	LAMC-ACO							LAMS-ACO						
	1	2	4	5	6	8	10	1	2	4	5	6	8	10
F_1	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**
F_2	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**
F_3	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**
F_4	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**
F_5	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**
F_6	0.996	0.999	0.998	**1.000**	0.998	0.999	0.999	0.984	0.990	0.985	0.990	0.987	**0.993**	0.989
F_7	0.731	0.743	0.748	**0.754**	0.723	0.739	0.736	0.694	0.683	0.687	0.697	0.692	0.693	**0.704**
F_8	0.504	0.639	0.707	0.716	**0.722**	0.706	0.712	0.722	0.765	**0.782**	0.767	0.769	0.765	0.744
F_9	**0.294**	0.290	0.289	0.290	0.287	0.280	0.278	0.252	0.254	**0.262**	0.257	0.257	0.252	0.252
F_{10}	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	0.998	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**
F_{11}	**0.676**	0.670	0.667	0.667	0.667	0.667	0.667	**0.977**	0.961	0.928	0.902	0.902	0.876	0.846
F_{12}	**0.779**	0.770	0.750	0.752	0.750	0.750	0.750	**0.985**	0.983	0.980	**0.985**	0.983	0.975	**0.985**
F_{13}	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.683**	0.670	0.667	0.667	0.667	0.667	0.667
F_{14}	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**
F_{15}	0.728	**0.740**	0.738	0.730	0.728	0.723	0.703	**0.748**	**0.748**	**0.748**	**0.748**	0.745	0.745	0.740
F_{16}	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**
F_{17}	0.618	0.608	**0.625**	0.620	0.593	0.588	0.608	0.694	**0.708**	0.686	0.681	0.696	0.674	0.667
F_{18}	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**
F_{19}	0.493	**0.500**	0.495	0.495	0.498	0.495	0.495	0.500	0.502	0.500	0.498	**0.507**	0.502	0.502
F_{20}	0.257	**0.267**	**0.267**	**0.267**	0.257	0.243	0.240	0.338	**0.346**	0.343	0.331	0.338	0.336	0.314

I. Time Complexity Analysis

As for the complexity[1], given that the ant colony size is NP, the dimension size is D, the niche size is NS and the number of sampled points in local search is N, LAMC-ACO and LAMS-ACO outlined in **Algorithm 6** and **Algorithm 7** respectively, take $O(NP\times D)$ in Step 1, $O(NP)$ in Step 2 and constant time in Step 3. In Step 4, LAMC-ACO takes $O((NP+1)\times D+NP^2\times D)$ with each item corresponding to each step in **Algorithm 1**, while LAMS-ACO needs $O(NP\times log(NP)+NP^2\times D)$ with each item associated with each step in **Algorithm 2**. In Step 5, both algorithms need $O(NP+NP\times log(NS)+NP\times D)$ as in **Algorithm 4**. When it comes to Step 6, LAMC-ACO takes $O(NP^2\times D)$, while LAMS-ACO needs $O(NS\times NP\times D)$. For the local search in Step 7, both algorithms take $O(NP/NS\times N\times D)$.

Overall, since NP/NS, NS and N are much smaller than NP, we can see that the total complexities of both LAMC-ACO and LAMS-ACO are $O(NP^2\times D)$, which is linearly proportional to the dimension size D.

II. Preliminary Experiments

This section mainly presents the preliminary experiments, which are designed for setting the parameters in the proposed LAM-ACOs. Except for the population size, which is a common problem-dependent parameter for all EAs, three parameters need to be set in LAM-ACOs, namely the niche size set $\boldsymbol{G}$, the standard deviation δ and the number of sampled points N for the local search. In this paper, the population size is set according to [46], which adopts the same benchmark multimodal function suite. Thus, we only present the sensitivity analysis about $\boldsymbol{G}$, δ and N in the preliminary experiments, which are shown as below. When conducting experiments on the sensitivity analysis about one parameter, the others are set as the default values presented in Table SII. It is worth mentioning that all experimental results are averaged over 51 independent runs.

A. *Sensitivity to the Niche Size Set* $\boldsymbol{G}$

As different problems have different features, the optimal niche size for different multimodal problems may be different. Besides, for a given problem, at different evolution stages, this niche size even may be different, since different sub-regions may have different fitness landscapes. Consequently, to alleviate the sensitivity to the niche size for LAM-ACOs, we add a random-based niche size setting for the niching methods used in LAM-ACOs. Specifically, we predefine a niche size set $\boldsymbol{G}$, which contains different integers representing different niche sizes. During each generation, a niche size is randomly selected from $\boldsymbol{G}$.

Through this, a potential balance between exploration and exploitation can be obtained. This is because during evolution, when ants in one niche fall into local areas, a larger niche size selected at the following generations would introduce more solutions for ants to construct new solutions. This can potentially enhance the diversity of the niches and afford a chance for ants to escape from local areas. Thus the exploration ability of the algorithm is enhanced. On the contrary, when the niches contain too many solutions for ants to construct solutions caused by a large niche size, a smaller niche size selected at the following generations would reduce the number of solutions in the niches, potentially leading to narrow search space for ants to exploit. Thus, it may be beneficial for the enhancement of exploitation ability.

Thus, we can see that $\boldsymbol{G}$ should contain small and large integers simultaneously, so that the potential balance between exploration and exploitation can be achieved. To observe the sensitivity of LAM-ACOs to the niche size set $\boldsymbol{G}$, we conduct experiments on LAM-ACOs by setting $\boldsymbol{G}$ as different ranges of integers, such as [2,5], [2,10], [10,30], etc. For simplicity, we only display the experimental results at the accuracy level ε=1.0E-04, which are shown in Table SIII.

From this table, we can see that both LAMC-ACO and LAMS-ACO are not sensitive to $\boldsymbol{G}$ if we keep it in a wide range containing both small and large integers. More specifically, we can find that LAMC-ACO or LAMS-ACO can obtain very similar performance when $\boldsymbol{G}$ is set as [2, 5], [2, 10], [2, 20], and [2, 30] respectively. However, when the integers in $\boldsymbol{G}$ are too large, such as $\boldsymbol{G}$=[10, 30], both LAMC-ACO and LAMS-ACO degrade significantly on some functions, like F_6- F_9, F_{11} and F_{12}. This is because such ranges containing only large integers cannot provide the potential balance between exploration and exploitation for LAM-ACOs.

To summarize, a good setting of $\boldsymbol{G}$ is a wide range containing small and large integers. Specifically, we find $\boldsymbol{G}$ =[2,20] is enough for both LAMC-ACO and LAMS-ACO.

B. *Sensitivity to the Standard Deviation* δ *for the Local Search*

Generally, ACO needs a specific local search method to enhance its exploitation ability, so that the obtained solution can be refined. Since this paper aims to locate multiple global optima simultaneously, we conduct local search on the seeds of niches adaptively, so that multiple solutions can be refined during each generation.

In this paper, we realize the local search scheme by utilizing Gaussian distribution to sample points around the seeds of niches, because this distribution has a narrow sampling space, especially when the standard deviation δ is small. Thus, naturally, the standard deviation δ for the local search scheme should be small, so that better solutions can be found around the seeds. To observe the influence of the standard deviation δ on the proposed LAM-ACOs, we conduct experiments by varying δ from 1.0E-01 to 1.0E-05. For brevity, we only report the experimental results at the accuracy level ε=1.0E-04, which are shown in Table SIV.

[1] When conducting complexity analysis for EAs, we mainly pay attention to the extra time complexity in the algorithm with the time complexity of function evaluations excluded, which is problem-dependent.

From this table, we can see that when δ is too large, such as δ=1.0E-01 or δ=1.0E-02, LAMC-ACO performs very poorly on some functions, such as F_6, F_8, F_{12}, F_{17}, and F_{20}, and LAMS-ACO also only locates a small number of global optima on F_8, and F_{17}. This is because, a large δ leads to large sampling space for Gaussian distribution, which is not beneficial for the local search method to refine the obtained solutions. When δ is small, such as δ=1.0E-03, δ=1.0E-04 and δ=1.0E-05, we can see that both LAMC-ACO and LAMS-ACO are not so sensitive to δ, since LAMC-ACO and LAMS-ACO with different small δ obtain very similar performance. This is because a small δ affords narrow sampling space for Gaussian distribution, which is beneficial for the local search method to search around the seeds of niches. However, compared with δ=1.0E-03 and δ=1.0E-05, both LAMC-ACO and LAMS-ACO with δ=1.0E-04 can obtain the best performance on most of the functions.

In a word, we can see that to refine the obtained solutions, δ should be small for the local search method. Specifically, δ=1.0E-04 is enough for the proposed LAM-ACOs.

C. *Sensitivity to the Number of Sampled Points N for the Local Search*

To enhance the probability that the solution accuracy is promoted, enough points should be sampled when conducting the local search. However, the number of sampled points (termed as N) should be neither too large nor too small. A too large number would waste fitness evaluations, especially when the local search is carried out around local areas. In contrast, a too small number may not afford the improvement of solutions.

Thus, to investigate the influence of the number of sampled points N on the proposed LAM-ACOs, we conduct experiments by varying N from 1 to 10. For simplicity, we only report the experimental results at the accuracy level ε=1.0E-04, which are shown in Table SV.

From this table, we can see that both LAMC-ACO and LAMS-ACO are not so sensitive to N since LAMC-ACO and LAS-ACO with different settings of N can achieve very similar performance. Specifically, we can find that both LAMC-ACO and LAMS-ACO with N=2 achieve the best performance on most of the functions. Thus, in this paper, N=2 is utilized.

III. Experimental Results

TABLE SVI
COMPARISON RESULTS WITH RESPECT TO PR AMONG AM-ACO, DE AND PSO WITH THE SAME NICHING METHODS AT ACCURACY LEVEL ε=1.0E-04.

1.0E-04						
F	CC_PSO	Self_CCDE	AMC-ACO	CS_PSO	Self_CSDE	AMS-ACO
F_1	0.892	**1.000**	**1.000**	0.745	**1.000**	**1.000**
F_2	0.690	**1.000**	**1.000**	0.875	**1.000**	**1.000**
F_3	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**
F_4	0.000	**1.000**	**1.000**	0.000	0.686	**1.000**
F_5	0.902	**1.000**	**1.000**	0.853	0.961	**1.000**
F_6	0.001	**0.942**	0.114	0.000	0.699	**0.956**
F_7	0.065	**0.884**	0.734	0.068	**0.695**	0.680
F_8	0.000	**0.994**	0.000	0.000	**0.695**	0.293
F_9	0.000	**0.459**	0.291	0.000	**0.265**	0.261
F_{10}	0.013	**1.000**	**1.000**	0.021	0.992	**0.997**
F_{11}	0.000	**0.778**	0.673	0.000	0.399	**0.954**
F_{12}	0.000	**0.422**	0.390	0.000	0.321	**0.929**
F_{13}	0.000	0.660	**0.667**	0.003	0.317	**0.676**
F_{14}	0.000	0.657	**0.667**	0.000	0.304	**0.667**
F_{15}	0.000	0.343	**0.380**	0.000	0.186	**0.679**
F_{16}	0.000	0.657	**0.667**	0.000	0.072	**0.667**
F_{17}	0.000	0.248	**0.292**	0.000	0.056	**0.422**
F_{18}	0.000	0.337	**0.657**	0.000	0.003	**0.667**
F_{19}	0.000	0.113	**0.370**	0.000	0.000	**0.495**
F_{20}	0.000	**0.027**	0.005	0.000	0.000	**0.240**

TABLE SVII
COMPARISON RESULTS WITH RESPECT TO PR AMONG DIFFERENT VERSIONS OF LAM-ACOS AT ACCURACY LEVEL ε=1.0E-04.

1.0E-04								
F	AMC-ACO		LAMC-ACO		AMS-ACO		LAMS-ACO	
	WDE	DE	WDE	DE	WDE	DE	WDE	DE
F_1	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**
F_2	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**
F_3	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**
F_4	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**
F_5	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**
F_6	0.114	0.098	**1.000**	0.999	0.956	0.936	**0.993**	0.990
F_7	0.734	0.702	**0.748**	0.743	0.680	0.668	**0.715**	0.683
F_8	0.000	0.000	**0.686**	0.639	0.293	0.330	**0.777**	0.765
F_9	0.291	0.279	**0.306**	0.290	0.261	0.242	**0.273**	0.254
F_{10}	**1.000**	**1.000**	**1.000**	**1.000**	0.997	0.995	**1.000**	**1.000**
F_{11}	0.673	**0.729**	0.667	0.670	0.954	**0.974**	0.931	0.961
F_{12}	0.390	0.473	0.752	**0.770**	0.929	0.922	**0.985**	0.983
F_{13}	**0.667**	**0.667**	**0.667**	**0.667**	0.676	**0.699**	0.667	0.670
F_{14}	**0.667**	**0.667**	**0.667**	**0.667**	0.667	**0.670**	0.667	0.667
F_{15}	0.380	0.387	0.689	**0.740**	0.679	0.711	0.743	**0.748**
F_{16}	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**
F_{17}	0.292	0.373	0.542	**0.608**	0.422	0.532	0.640	**0.708**
F_{18}	0.657	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**
F_{19}	0.370	0.495	0.480	**0.500**	0.495	0.498	0.495	**0.502**
F_{20}	0.005	**0.267**	0.047	**0.267**	0.240	0.331	0.211	**0.346**

TABLE SVIII
COMPARISON RESULTS WITH RESPECT TO CS AMONG DIFFERENT VERSIONS OF LAM-ACOS AT ACCURACY LEVEL ε=1.0E-04.

1.0E-04								
F	AMC-ACO		LAMC-ACO		AMS-ACO		LAMS-ACO	
	WDE	DE	WDE	DE	WDE	DE	WDE	DE
F_1	2.26E+02	**2.12E+02**	2.61E+02	2.59E+02	2.20E+02	**2.01E+02**	2.64E+02	2.14E+02
F_2	9.79E+02	1.01E+03	9.20E+02	**7.87E+02**	9.08E+02	8.35E+02	8.39E+02	**7.78E+02**
F_3	7.29E+02	7.07E+02	5.09E+02	**5.03E+02**	6.34E+02	5.51E+02	5.61E+02	**5.07E+02**
F_4	6.48E+03	**5.89E+03**	7.60E+03	6.47E+03	4.48E+03	**3.77E+03**	5.40E+03	4.62E+03
F_5	2.54E+03	**2.02E+03**	2.95E+03	2.51E+03	1.91E+03	**1.48E+03**	2.13E+03	1.83E+03

TABLE SIX

COMPARISON RESULTS OF LAM-ACOS WITH DYNAMIC NICHE SIZING OR A FIXED NICHE SIZE AT ACCURACY LEVEL ε=1.0E-04.

F	1.0E-04													
	LAMC-ACO							LAMS-ACO						
	2	4	8	12	16	20	Random	2	4	8	12	16	20	Random
F_1	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**
F_2	**1.000**	**1.000**	**1.000**	**1.000**	0.996	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	0.988	**1.000**
F_3	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**
F_4	**1.000**	**1.000**	**1.000**	**1.000**	0.995	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**
F_5	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**
F_6	0.999	**1.000**	0.960	0.833	0.717	0.553	0.999	0.976	0.969	0.803	0.624	0.528	0.353	**0.990**
F_7	**0.758**	0.693	0.673	0.606	0.587	0.545	0.743	**0.725**	0.654	0.600	0.543	0.535	0.493	0.683
F_8	**0.804**	0.712	0.515	0.390	0.316	0.258	0.639	0.764	0.704	0.437	0.315	0.256	0.215	**0.765**
F_9	**0.336**	0.286	0.228	0.195	0.174	0.162	0.290	**0.301**	0.243	0.188	0.157	0.141	0.122	0.254
F_{10}	**1.000**	0.998	0.995	0.977	0.969	0.936	**1.000**	0.997	0.997	0.989	0.882	0.856	0.719	**1.000**
F_{11}	**0.980**	0.856	0.667	0.667	0.667	0.667	0.670	0.977	**0.990**	0.794	0.670	0.667	0.667	0.961
F_{12}	**0.980**	0.973	0.752	0.745	0.733	0.716	0.770	0.963	**0.995**	0.973	0.855	0.757	0.708	0.983
F_{13}	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	0.667	**0.722**	0.667	0.667	0.667	0.667	0.670
F_{14}	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**
F_{15}	0.608	0.701	0.743	**0.750**	**0.750**	0.740	0.740	0.645	0.718	0.738	**0.748**	**0.748**	0.743	**0.748**
F_{16}	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	0.654	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**	**0.667**
F_{17}	0.466	0.576	0.630	**0.637**	0.608	0.515	0.608	0.434	0.593	0.684	**0.733**	0.708	0.713	0.708
F_{18}	0.614	**0.667**	0.660	0.663	0.660	0.650	**0.667**	0.114	0.644	0.650	**0.667**	**0.667**	**0.667**	**0.667**
F_{19}	0.451	**0.500**	0.488	0.466	0.471	0.407	**0.500**	0.127	0.449	0.500	0.500	**0.505**	0.502	0.502
F_{20}	0.132	**0.299**	0.265	0.240	0.223	0.169	0.267	0.000	0.252	0.270	0.252	0.248	0.223	**0.346**

TABLE SX

COMPARISON RESULTS WITH RESPECT TO PR AND SR BETWEEN LAMC-ACO AND LAMS-ACO AT ALL FIVE ACCURACY LEVELS.

ε	F_1				F_2				F_3				F_4				F_5			
	LAMC-ACO		LAMS-ACO		LAMC-ACO		LAMS-ACO		LAMC-ACO		LAMS-ACO		LAMC-ACO		LAMS-ACO		LAMC-ACO		LAMS-ACO	
	PR	SR	PR	SR	PR	SR	PR	SR	PR	SR	PR	SR	PR	SR	PR	SR	PR	SR	PR	SR
1.0E-01	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000
1.0E-02	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000
1.0E-03	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000
1.0E-04	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000
1.0E-05	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000

ε	F_6				F_7				F_8				F_9				F_{10}			
	LAMC-ACO		LAMS-ACO		LAMC-ACO		LAMS-ACO		LAMC-ACO		LAMS-ACO		LAMC-ACO		LAMS-ACO		LAMC-ACO		LAMS-ACO	
	PR	SR	PR	SR	PR	SR	PR	SR	PR	SR	PR	SR	PR	SR	PR	SR	PR	SR	PR	SR
1.0E-01	**0.999**	0.980	0.992	0.863	**1.000**	1.000	**1.000**	1.000	0.737	0.000	**0.803**	0.000	**0.401**	0.000	0.350	0.000	**1.000**	1.000	**1.000**	1.000
1.0E-02	**0.999**	0.980	0.992	0.863	**0.832**	0.000	0.763	0.000	0.696	0.000	**0.791**	0.000	**0.393**	0.000	0.336	0.000	**1.000**	1.000	**1.000**	1.000
1.0E-03	**0.999**	0.980	0.990	0.824	**0.789**	0.000	0.716	0.000	0.680	0.000	**0.782**	0.000	**0.348**	0.000	0.295	0.000	**1.000**	1.000	**1.000**	1.000
1.0E-04	**0.999**	0.980	0.990	0.824	**0.743**	0.000	0.683	0.000	0.639	0.000	**0.765**	0.000	**0.290**	0.000	0.254	0.000	**1.000**	1.000	**1.000**	1.000
1.0E-05	**0.999**	0.980	0.990	0.824	**0.714**	0.000	0.660	0.000	0.403	0.000	**0.647**	0.000	**0.256**	0.000	0.235	0.000	**1.000**	1.000	**1.000**	1.000

ε	F_{11}				F_{12}				F_{13}				F_{14}				F_{15}			
	LAMC-ACO		LAMS-ACO		LAMC-ACO		LAMS-ACO		LAMC-ACO		LAMS-ACO		LAMC-ACO		LAMS-ACO		LAMC-ACO		LAMS-ACO	
	PR	SR	PR	SR	PR	SR	PR	SR	PR	SR	PR	SR	PR	SR	PR	SR	PR	SR	PR	SR
1.0E-01	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000	0.985	0.882	**0.993**	0.980	**0.993**	0.980	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000	0.995	0.980
1.0E-02	0.886	0.373	**0.984**	0.902	**0.985**	0.882	0.983	0.863	0.667	0.000	**0.693**	0.000	**0.667**	0.000	**0.667**	0.000	0.740	0.000	**0.748**	0.000
1.0E-03	0.683	0.000	**0.974**	0.843	0.824	0.098	**0.983**	0.863	0.667	0.000	**0.676**	0.000	**0.667**	0.000	**0.667**	0.000	0.740	0.000	**0.748**	0.000
1.0E-04	0.670	0.000	**0.961**	0.765	0.770	0.000	**0.983**	0.863	0.667	0.000	**0.670**	0.000	**0.667**	0.000	**0.667**	0.000	0.740	0.000	**0.748**	0.000
1.0E-05	0.670	0.000	**0.944**	0.667	0.750	0.000	**0.980**	0.843	**0.667**	0.000	**0.667**	0.000	**0.667**	0.000	**0.667**	0.000	0.730	0.000	**0.748**	0.000

ε	F_{16}				F_{17}				F_{18}				F_{19}				F_{20}			
	LAMC-ACO		LAMS-ACO		LAMC-ACO		LAMS-ACO		LAMC-ACO		LAMS-ACO		LAMC-ACO		LAMS-ACO		LAMC-ACO		LAMS-ACO	
	PR	SR	PR	SR	PR	SR	PR	SR	PR	SR	PR	SR	PR	SR	PR	SR	PR	SR	PR	SR
1.0E-01	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000	0.988	0.961	**1.000**	1.000	**1.000**	1.000	**0.919**	0.843	0.897	0.784	**0.672**	0.529	0.632	0.451
1.0E-02	**0.667**	0.000	**0.667**	0.000	0.613	0.000	**0.708**	0.000	**0.667**	0.000	**0.667**	0.000	0.500	0.000	**0.502**	0.000	0.272	0.000	**0.348**	0.000
1.0E-03	**0.667**	0.000	**0.667**	0.000	0.608	0.000	**0.708**	0.000	**0.667**	0.000	**0.667**	0.000	0.500	0.000	**0.502**	0.000	0.272	0.000	**0.348**	0.000
1.0E-04	**0.667**	0.000	**0.667**	0.000	0.608	0.000	**0.708**	0.000	**0.667**	0.000	**0.667**	0.000	0.500	0.000	**0.502**	0.000	0.267	0.000	**0.346**	0.000
1.0E-05	**0.667**	0.000	**0.667**	0.000	0.505	0.000	**0.625**	0.000	**0.667**	0.000	**0.667**	0.000	0.498	0.000	**0.502**	0.000	0.245	0.000	**0.333**	0.000

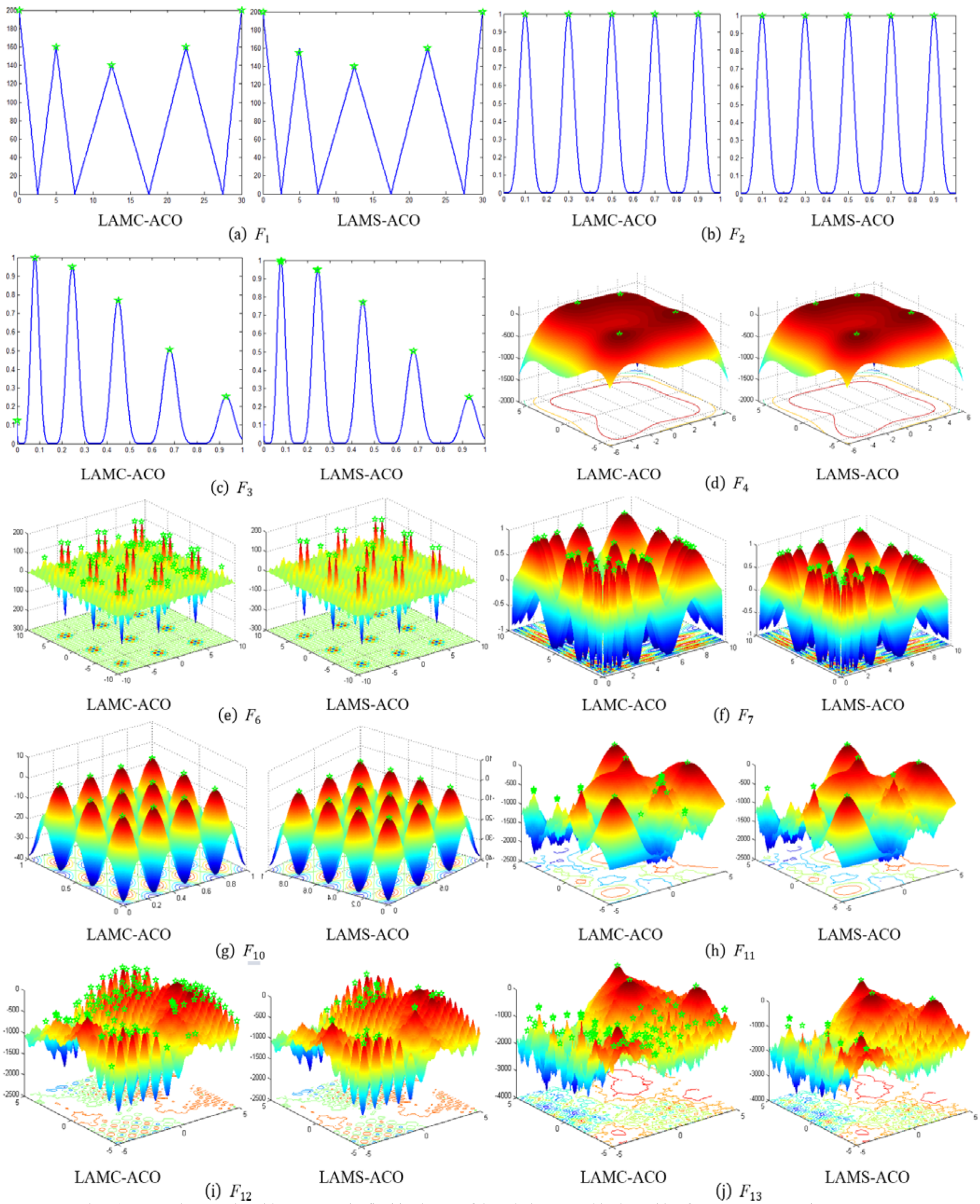


Fig. S1. Comparison results with respect to the final landscape of the solutions stored in the archive for LAMC-ACO and LAMS-ACO.

*In the following five tables (Tables SXI-SXV), the results of each algorithm with respect to PR, SR, and CS are presented with each table associated with one accuracy level. The best PRs are highlighted in bold, and the last row of each table, termed "bprs" counts the number of the best PRs each algorithm obtains on the total 20 functions, namely the number of the bolded PRs. Table SXVI presents the change of "bprs" of different algorithms with the accuracy level increasing.

TABLE SXI
COMPARISON RESULTS IN PR, SR AND CS BETWEEN LAM-ACOS AND STATE-OF-THE-ART MULTIMODAL METHODS ON TOTAL 20 FUNCTIONS AT ACCURACY LEVEL ε=1.0E-01. THE BEST PR IS HIGHLIGHTED IN BOLD.

1.0E-01																					
F	CDE			SDE			LIPS			R2PSO			NCDE			NSDE			Self_CCDE		
	PR	SR	CS	PR	SR	CS	PR	SR	CS	PR	SR	CS	PR	SR	CS	PR	SR	CS	PR	SR	CS
F_1	**1.000**	1.000	1.60E+2	0.657	0.373	3.24E+4	0.833	0.686	1.64E+4	**1.000**	1.000	1.88E+2	**1.000**	1.000	6.85E+2	**1.000**	1.000	2.39E+2	**1.000**	1.000	3.55E+2
F_2	**1.000**	1.000	9.73E+1	**1.000**	1.000	1.05E+2	**1.000**	1.000	1.22E+2	**1.000**	1.000	9.41E+1	**1.000**	1.000	9.73E+1	**1.000**	1.000	9.73E+1	**1.000**	1.000	1.04E+2
F_3	**1.000**	1.000	8.78E+1	**1.000**	1.000	8.74E+1	**1.000**	1.000	8.63E+1	**1.000**	1.000	8.94E+1	**1.000**	1.000	8.16E+1	**1.000**	1.000	8.31E+1	**1.000**	1.000	8.78E+1
F_4	**1.000**	1.000	7.32E+3	**1.000**	1.000	2.43E+3	**1.000**	1.000	8.89E+2	**1.000**	1.000	1.61E+3	**1.000**	1.000	1.65E+3	**1.000**	1.000	7.16E+2	**1.000**	1.000	2.43E+3
F_5	**1.000**	1.000	2.54E+2	**1.000**	1.000	1.90E+2	**1.000**	1.000	2.54E+2	**1.000**	1.000	2.82E+2	**1.000**	1.000	2.38E+2	0.990	0.980	1.20E+3	**1.000**	1.000	2.90E+2
F_6	**1.000**	1.000	5.82E+4	0.056	0.000	2.00E+5	0.276	0.000	2.00E+5	0.791	0.000	2.00E+5	0.914	0.255	1.80E+5	0.058	0.000	2.00E+5	0.998	0.961	4.97E+4
F_7	**1.000**	1.000	3.03E+3	**1.000**	1.000	1.35E+3	0.976	0.961	9.44E+3	**1.000**	1.000	2.70E+3	**1.000**	1.000	2.36E+3	**1.000**	1.000	1.35E+3	**1.000**	1.000	2.55E+3
F_8	0.112	0.000	4.00E+5	0.015	0.000	4.00E+5	0.086	0.000	4.00E+5	0.182	0.000	4.00E+5	0.603	0.000	4.00E+5	0.013	0.000	4.00E+5	0.999	0.922	1.80E+5
F_9	0.600	0.216	3.23E+5	0.011	0.000	4.00E+5	0.105	0.000	4.00E+5	0.226	0.000	4.00E+5	0.465	0.000	4.00E+5	0.006	0.000	4.00E+5	0.482	0.000	4.00E+5
F_{10}	**1.000**	1.000	5.35E+3	0.229	0.098	1.81E+5	0.781	0.216	1.57E+5	0.977	0.824	4.36E+4	**1.000**	1.000	3.84E+3	0.098	0.000	2.00E+5	**1.000**	1.000	2.83E+3
F_{11}	**1.000**	1.000	8.46E+4	0.944	0.922	2.15E+4	**1.000**	1.000	4.09E+3	**1.000**	1.000	7.96E+3	**1.000**	1.000	1.03E+4	**1.000**	1.000	2.55E+3	**1.000**	1.000	1.74E+4
F_{12}	0.255	0.000	2.00E+5	0.208	0.000	2.00E+5	0.596	0.000	2.00E+5	0.581	0.000	2.00E+5	0.968	0.784	1.47E+5	0.135	0.000	2.00E+5	0.961	0.686	1.29E+5
F_{13}	**1.000**	1.000	1.39E+5	0.618	0.471	1.09E+5	0.941	0.745	5.49E+4	0.997	0.980	1.69E+4	0.892	0.627	1.05E+5	0.608	0.490	1.03E+5	0.993	0.980	5.83E+4
F_{14}	**1.000**	1.000	2.65E+5	0.938	0.922	4.13E+4	0.990	0.980	1.39E+4	**1.000**	1.000	1.64E+4	**1.000**	1.000	2.25E+4	0.984	0.980	1.19E+4	**1.000**	1.000	3.06E+4
F_{15}	0.985	0.980	3.03E+5	0.581	0.549	1.87E+5	0.537	0.333	2.70E+5	0.814	0.686	1.87E+5	**1.000**	1.000	1.57E+4	**1.000**	1.000	4.14E+3	**1.000**	1.000	6.20E+4
F_{16}	0.212	0.039	3.99E+5	0.647	0.647	1.72E+5	**1.000**	1.000	8.74E+3	0.660	0.569	2.66E+5	**1.000**	1.000	2.22E+4	**1.000**	1.000	6.90E+3	**1.000**	1.000	3.49E+4
F_{17}	0.005	0.000	4.00E+5	0.574	0.569	2.02E+5	0.257	0.118	3.54E+5	0.110	0.039	3.90E+5	**1.000**	1.000	2.43E+4	0.863	0.863	6.08E+4	0.963	0.922	1.36E+5
F_{18}	**1.000**	1.000	1.90E+5	0.157	0.157	3.69E+5	0.725	0.725	1.20E+5	0.359	0.314	3.30E+5	**1.000**	1.000	3.64E+4	0.980	0.980	2.18E+4	**1.000**	1.000	6.15E+4
F_{19}	0.000	0.000	4.00E+5	0.145	0.039	3.93E+5	0.010	0.000	4.00E+5	0.017	0.000	4.00E+5	0.811	0.745	2.43E+5	0.098	0.000	4.00E+5	0.404	0.039	3.96E+5
F_{20}	0.000	0.000	4.00E+5	0.000	0.000	4.00E+5	0.000	0.000	4.00E+5	0.027	0.000	4.00E+5	**1.000**	1.000	9.36E+4	0.980	0.980	4.07E+4	0.463	0.176	3.71E+5
bprs	12			5			6			8			14			8			12		

F	Self_CSDE			LoICDE			LoISDE			PNPCDE			MOMMOP			LAMC-ACO			LAMS-ACO		
	PR	SR	CS	PR	SR	CS	PR	SR	CS	PR	SR	CS	PR	SR	CS	PR	SR	CS	PR	SR	CS
F_1	**1.000**	1.000	7.07E+2	**1.000**	1.000	1.73E+2	**1.000**	1.000	1.68E+2	**1.000**	1.000	1.62E+2	**1.000**	1.000	1.66E+2	**1.000**	1.000	2.59E+2	**1.000**	1.000	2.12E+2
F_2	**1.000**	1.000	1.22E+2	**1.000**	1.000	1.00E+2	**1.000**	1.000	9.57E+1	**1.000**	1.000	9.73E+1	**1.000**	1.000	1.05E+2	**1.000**	1.000	9.69E+1	**1.000**	1.000	1.05E+2
F_3	**1.000**	1.000	9.25E+1	**1.000**	1.000	8.63E+1	**1.000**	1.000	8.47E+1	**1.000**	1.000	8.47E+1	**1.000**	1.000	8.47E+1	**1.000**	1.000	9.45E+1	**1.000**	1.000	8.55E+1
F_4	**1.000**	1.000	3.03E+3	**1.000**	1.000	2.91E+3	**1.000**	1.000	8.61E+2	**1.000**	1.000	5.14E+3	**1.000**	1.000	2.50E+4	**1.000**	1.000	1.63E+3	**1.000**	1.000	1.29E+3
F_5	**1.000**	1.000	4.36E+2	**1.000**	1.000	1.95E+2	**1.000**	1.000	2.07E+2	**1.000**	1.000	2.98E+2	**1.000**	1.000	7.98E+2	**1.000**	1.000	2.38E+2	**1.000**	1.000	2.30E+2
F_6	0.855	0.176	1.77E+5	**1.000**	1.000	5.15E+4	0.056	0.000	2.00E+5	**1.000**	1.000	1.01E+5	**1.000**	1.000	5.04E+4	0.999	0.980	7.39E+4	0.992	0.863	8.49E+4
F_7	**1.000**	1.000	2.48E+3	**1.000**	1.000	2.61E+3	**1.000**	1.000	1.51E+3	**1.000**	1.000	2.86E+3	**1.000**	1.000	2.71E+4	**1.000**	1.000	2.74E+3	**1.000**	1.000	2.82E+3
F_8	0.695	0.000	4.00E+5	0.214	0.000	4.00E+5	0.012	0.000	4.00E+5	0.038	0.000	4.00E+5	**1.000**	1.000	2.28E+5	0.737	0.000	4.00E+5	0.803	0.000	4.00E+5
F_9	0.265	0.000	4.00E+5	0.518	0.078	3.72E+5	0.005	0.000	4.00E+5	0.516	0.078	3.71E+5	**1.000**	1.000	7.98E+4	0.401	0.000	4.00E+5	0.350	0.000	4.00E+5
F_{10}	**1.000**	1.000	2.70E+3	**1.000**	1.000	5.33E+3	0.083	0.000	2.00E+5	**1.000**	1.000	5.17E+3	**1.000**	1.000	3.44E+4	**1.000**	1.000	3.33E+3	**1.000**	1.000	3.58E+3
F_{11}	0.997	0.980	3.01E+4	**1.000**	1.000	1.82E+4	0.967	0.961	1.11E+4	**1.000**	1.000	6.09E+4	**1.000**	1.000	5.83E+4	**1.000**	1.000	9.00E+3	**1.000**	1.000	6.21E+3
F_{12}	0.699	0.118	1.85E+5	0.750	0.000	2.00E+5	0.125	0.000	2.00E+5	0.331	0.000	2.00E+5	0.975	0.804	1.33E+5	**1.000**	1.000	1.15E+5	0.985	0.882	7.63E+4
F_{13}	0.863	0.549	1.29E+5	0.980	0.941	5.31E+4	0.330	0.196	1.62E+5	**1.000**	1.000	1.11E+5	**1.000**	1.000	7.49E+4	0.993	0.980	2.64E+4	0.993	0.980	1.50E+4
F_{14}	0.993	0.980	4.91E+4	**1.000**	1.000	2.39E+4	0.984	0.980	1.28E+4	**1.000**	1.000	1.99E+5	**1.000**	1.000	1.20E+5	**1.000**	1.000	1.86E+4	**1.000**	1.000	1.11E+4
F_{15}	0.605	0.157	3.55E+5	**1.000**	1.000	1.40E+4	**1.000**	1.000	4.58E+3	**1.000**	1.000	2.22E+5	0.743	0.235	3.55E+5	**1.000**	1.000	2.40E+4	0.995	0.980	2.27E+4
F_{16}	0.990	0.980	7.53E+4	**1.000**	1.000	3.30E+4	**1.000**	1.000	1.14E+4	0.801	0.667	3.68E+5	**1.000**	1.000	1.50E+5	**1.000**	1.000	2.79E+4	**1.000**	1.000	1.84E+4
F_{17}	0.343	0.078	3.78E+5	**1.000**	1.000	3.13E+4	0.608	0.608	1.62E+5	0.044	0.000	4.00E+5	**1.000**	1.000	2.84E+5	**1.000**	1.000	3.76E+4	0.988	0.961	4.01E+4
F_{18}	0.611	0.490	2.85E+5	**1.000**	1.000	4.39E+4	0.941	0.941	4.15E+4	**1.000**	1.000	2.50E+5	**1.000**	1.000	1.68E+5	**1.000**	1.000	5.34E+4	**1.000**	1.000	3.83E+4
F_{19}	0.012	0.000	4.00E+5	0.120	0.000	4.00E+5	0.044	0.020	3.92E+5	0.000	0.000	4.00E+5	0.223	0.000	4.00E+5	**0.919**	0.843	1.69E+5	0.897	0.784	1.57E+5
F_{20}	0.000	0.000	4.00E+5	**1.000**	1.000	1.37E+5	0.672	0.667	1.65E+5	0.000	0.000	4.00E+5	**1.000**	1.000	1.60E+5	0.672	0.529	2.81E+5	0.632	0.451	3.05E+5
bprs	7			15			8			13			17			15			11		

TABLE SXII

COMPARISON RESULTS IN PR, SR AND CS BETWEEN LAM-ACOS AND STATE-OF-THE-ART MULTIMODAL METHODS ON TOTAL 20 FUNCTIONS AT ACCURACY LEVEL ε=1.0E-02. THE BEST PR IS HIGHLIGHTED IN BOLD.

1.0E-02																					
F	CDE			SDE			LIPS			R2PSO			NCDE			NSDE			Self_CCDE		
	PR	SR	CS	PR	SR	CS	PR	SR	CS	PR	SR	CS	PR	SR	CS	PR	SR	CS	PR	SR	CS
F_1	**1.000**	1.000	1.60E+2	0.657	0.373	3.24E+4	0.833	0.686	1.64E+4	**1.000**	1.000	1.88E+2	**1.000**	1.000	6.85E+2	**1.000**	1.000	2.39E+2	**1.000**	1.000	3.55E+2
F_2	**1.000**	1.000	4.36E+2	**1.000**	1.000	2.01E+2	**1.000**	1.000	3.04E+2	**1.000**	1.000	4.61E+2	**1.000**	1.000	4.58E+2	0.984	0.961	2.34E+3	**1.000**	1.000	4.02E+2
F_3	**1.000**	1.000	3.64E+2	**1.000**	1.000	2.58E+2	**1.000**	1.000	2.60E+2	**1.000**	1.000	2.85E+2	**1.000**	1.000	2.21E+2	**1.000**	1.000	4.09E+2	**1.000**	1.000	2.23E+2
F_4	**1.000**	1.000	1.61E+4	**1.000**	1.000	2.78E+3	**1.000**	1.000	1.49E+3	**1.000**	1.000	2.76E+3	**1.000**	1.000	2.60E+3	0.985	0.980	2.03E+3	**1.000**	1.000	4.15E+3
F_5	**1.000**	1.000	1.52E+3	**1.000**	1.000	7.18E+2	**1.000**	1.000	5.07E+2	**1.000**	1.000	8.09E+2	**1.000**	1.000	7.84E+2	0.951	0.902	5.31E+3	**1.000**	1.000	9.68E+2
F_6	**1.000**	1.000	8.56E+4	0.056	0.000	2.00E+5	0.257	0.000	2.00E+5	0.708	0.000	2.00E+5	0.733	0.000	2.00E+5	0.056	0.000	2.00E+5	0.991	0.843	9.45E+4
F_7	0.878	0.000	2.00E+5	0.054	0.000	2.00E+5	0.400	0.000	2.00E+5	0.579	0.000	2.00E+5	0.877	0.000	2.00E+5	0.053	0.000	2.00E+5	0.884	0.020	1.97E+5
F_8	0.005	0.000	4.00E+5	0.015	0.000	4.00E+5	0.085	0.000	4.00E+5	0.099	0.000	4.00E+5	0.109	0.000	4.00E+5	0.013	0.000	4.00E+5	0.997	0.902	2.10E+5
F_9	0.477	0.000	4.00E+5	0.011	0.000	4.00E+5	0.105	0.000	4.00E+5	0.204	0.000	4.00E+5	0.461	0.000	4.00E+5	0.006	0.000	4.00E+5	0.459	0.000	4.00E+5
F_{10}	**1.000**	1.000	1.23E+4	0.147	0.000	2.00E+5	0.758	0.020	1.96E+5	0.949	0.647	8.39E+4	0.993	0.922	3.05E+4	0.098	0.000	2.00E+5	**1.000**	1.000	5.11E+3
F_{11}	0.667	0.000	2.00E+5	0.314	0.000	2.00E+5	0.974	0.843	5.33E+4	0.650	0.000	2.00E+5	0.837	0.216	1.91E+5	0.248	0.000	2.00E+5	0.941	0.647	1.67E+5
F_{12}	0.032	0.000	2.00E+5	0.208	0.000	2.00E+5	0.583	0.000	2.00E+5	0.493	0.000	2.00E+5	0.718	0.118	1.97E+5	0.135	0.000	2.00E+5	0.819	0.216	1.88E+5
F_{13}	0.650	0.000	2.00E+5	0.297	0.000	2.00E+5	0.804	0.176	1.70E+5	0.657	0.000	2.00E+5	0.667	0.000	2.00E+5	0.225	0.000	2.00E+5	0.667	0.000	2.00E+5
F_{14}	0.598	0.000	4.00E+5	0.216	0.000	4.00E+5	0.644	0.000	4.00E+5	0.536	0.000	4.00E+5	0.667	0.000	4.00E+5	0.190	0.000	4.00E+5	0.667	0.000	4.00E+5
F_{15}	0.162	0.000	4.00E+5	0.108	0.000	4.00E+5	0.336	0.000	4.00E+5	0.194	0.000	4.00E+5	0.468	0.000	4.00E+5	0.125	0.000	4.00E+5	0.404	0.000	4.00E+5
F_{16}	0.010	0.000	4.00E+5	0.108	0.000	4.00E+5	0.307	0.000	4.00E+5	0.183	0.000	4.00E+5	**0.667**	0.000	4.00E+5	0.170	0.000	4.00E+5	**0.667**	0.000	4.00E+5
F_{17}	0.000	0.000	4.00E+5	0.076	0.000	4.00E+5	0.162	0.000	4.00E+5	0.034	0.000	4.00E+5	0.250	0.000	4.00E+5	0.108	0.000	4.00E+5	0.284	0.000	4.00E+5
F_{18}	0.167	0.000	4.00E+5	0.026	0.000	4.00E+5	0.121	0.000	4.00E+5	0.052	0.000	4.00E+5	0.513	0.000	4.00E+5	0.163	0.000	4.00E+5	0.392	0.000	4.00E+5
F_{19}	0.000	0.000	4.00E+5	0.110	0.000	4.00E+5	0.005	0.000	4.00E+5	0.005	0.000	4.00E+5	0.368	0.000	4.00E+5	0.098	0.000	4.00E+5	0.221	0.000	4.00E+5
F_{20}	0.000	0.000	4.00E+5	0.000	0.000	4.00E+5	0.000	0.000	4.00E+5	0.007	0.000	4.00E+5	0.250	0.000	4.00E+5	0.123	0.000	4.00E+5	0.137	0.000	4.00E+5
bprs	7			4			4			5			6			2			7		
F	Self_CSDE			LoICDE			LoISDE			PNPCDE			MOMMOP			LAMC-ACO			LAMS-ACO		
	PR	SR	CS	PR	SR	CS	PR	SR	CS	PR	SR	CS	PR	SR	CS	PR	SR	CS	PR	SR	CS
F_1	**1.000**	1.000	7.11E+2	**1.000**	1.000	1.73E+2	**1.000**	1.000	1.68E+2	**1.000**	1.000	1.62E+2	**1.000**	1.000	1.66E+2	**1.000**	1.000	2.59E+2	**1.000**	1.000	2.14E+2
F_2	**1.000**	1.000	5.40E+2	**1.000**	1.000	4.41E+2	0.847	0.804	1.00E+4	**1.000**	1.000	3.97E+2	**1.000**	1.000	3.92E+2	**1.000**	1.000	3.22E+2	**1.000**	1.000	2.78E+2
F_3	**1.000**	1.000	3.22E+2	**1.000**	1.000	2.45E+2	**1.000**	1.000	2.58E+2	**1.000**	1.000	3.37E+2	**1.000**	1.000	2.98E+2	**1.000**	1.000	2.25E+2	**1.000**	1.000	2.08E+2
F_4	**1.000**	1.000	5.79E+3	**1.000**	1.000	5.07E+3	**1.000**	1.000	1.22E+3	**1.000**	1.000	1.21E+4	**1.000**	1.000	3.04E+4	**1.000**	1.000	3.00E+3	**1.000**	1.000	2.13E+3
F_5	**1.000**	1.000	1.36E+3	**1.000**	1.000	6.51E+2	**1.000**	1.000	5.33E+2	**1.000**	1.000	1.33E+3	**1.000**	1.000	1.10E+4	**1.000**	1.000	6.65E+2	**1.000**	1.000	5.80E+2
F_6	0.812	0.078	1.91E+5	**1.000**	1.000	7.38E+4	0.056	0.000	2.00E+5	0.966	0.725	1.69E+5	**1.000**	1.000	5.32E+4	0.999	0.980	9.91E+4	0.992	0.863	9.81E+4
F_7	0.696	0.000	2.00E+5	0.881	0.020	1.99E+5	0.029	0.000	2.00E+5	0.875	0.000	2.00E+5	**1.000**	1.000	5.04E+4	0.832	0.000	2.00E+5	0.763	0.000	2.00E+5
F_8	0.695	0.000	4.00E+5	0.012	0.000	4.00E+5	0.012	0.000	4.00E+5	0.001	0.000	4.00E+5	**1.000**	1.000	2.56E+5	0.696	0.000	4.00E+5	0.791	0.000	4.00E+5
F_9	0.265	0.000	4.00E+5	0.474	0.000	4.00E+5	0.005	0.000	4.00E+5	0.473	0.000	4.00E+5	**1.000**	1.000	2.53E+5	0.393	0.000	4.00E+5	0.336	0.000	4.00E+5
F_{10}	**1.000**	1.000	7.03E+3	**1.000**	1.000	1.51E+4	0.083	0.000	2.00E+5	**1.000**	1.000	1.26E+4	**1.000**	1.000	3.96E+4	**1.000**	1.000	6.41E+3	**1.000**	1.000	6.46E+3
F_{11}	0.686	0.059	1.95E+5	0.667	0.000	2.00E+5	0.167	0.000	2.00E+5	0.667	0.000	2.00E+5	**0.997**	0.980	1.15E+5	0.886	0.373	1.94E+5	0.984	0.902	1.05E+5
F_{12}	0.522	0.000	2.00E+5	0.706	0.000	2.00E+5	0.125	0.000	2.00E+5	0.086	0.000	2.00E+5	0.971	0.765	1.55E+5	**0.985**	0.882	1.71E+5	0.983	0.863	9.11E+4
F_{13}	0.618	0.000	2.00E+5	0.667	0.000	2.00E+5	0.167	0.000	2.00E+5	0.667	0.000	2.00E+5	**0.958**	0.745	1.64E+5	0.667	0.000	2.00E+5	0.693	0.000	2.00E+5
F_{14}	0.627	0.000	4.00E+5	0.667	0.000	4.00E+5	0.167	0.000	4.00E+5	0.660	0.000	4.00E+5	**0.709**	0.000	4.00E+5	0.667	0.000	4.00E+5	0.667	0.000	4.00E+5
F_{15}	0.392	0.000	4.00E+5	0.422	0.000	4.00E+5	0.125	0.000	4.00E+5	0.304	0.000	4.00E+5	0.647	0.000	4.00E+5	0.740	0.000	4.00E+5	**0.748**	0.000	4.00E+5
F_{16}	0.422	0.000	4.00E+5	0.657	0.000	4.00E+5	0.167	0.000	4.00E+5	0.121	0.000	4.00E+5	0.650	0.000	4.00E+5	**0.667**	0.000	4.00E+5	**0.667**	0.000	4.00E+5
F_{17}	0.162	0.000	4.00E+5	0.248	0.000	4.00E+5	0.076	0.000	4.00E+5	0.000	0.000	4.00E+5	0.515	0.000	4.00E+5	0.613	0.000	4.00E+5	**0.708**	0.000	4.00E+5
F_{18}	0.085	0.000	4.00E+5	0.225	0.000	4.00E+5	0.157	0.000	4.00E+5	0.173	0.000	4.00E+5	0.497	0.000	4.00E+5	**0.667**	0.000	4.00E+5	**0.667**	0.000	4.00E+5
F_{19}	0.000	0.000	4.00E+5	0.086	0.000	4.00E+5	0.027	0.000	4.00E+5	0.000	0.000	4.00E+5	0.223	0.000	4.00E+5	0.500	0.000	4.00E+5	**0.502**	0.000	4.00E+5
F_{20}	0.000	0.000	4.00E+5	0.125	0.000	4.00E+5	0.088	0.000	4.00E+5	0.000	0.000	4.00E+5	0.125	0.000	4.00E+5	0.272	0.000	4.00E+5	**0.348**	0.000	4.00E+5
bprs	6			7			4			6			13			9			12		

TABLE SXIII

COMPARISON RESULTS IN PR, SR AND CS BETWEEN LAM-ACOS AND STATE-OF-THE-ART MULTIMODAL METHODS ON TOTAL 20 FUNCTIONS AT ACCURACY LEVEL ε=1.0E-03. THE BEST PR IS HIGHLIGHTED IN BOLD

1.0E-03																					
F	CDE			SDE			LIPS			R2PSO			NCDE			NSDE			Self_CCDE		
	PR	SR	CS	PR	SR	CS	PR	SR	CS	PR	SR	CS	PR	SR	CS	PR	SR	CS	PR	SR	CS
F_1	**1.000**	1.000	1.60E+2	0.657	0.373	3.24E+4	0.833	0.686	1.64E+4	**1.000**	1.000	1.88E+2	**1.000**	1.000	6.85E+2	**1.000**	1.000	2.39E+2	**1.000**	1.000	3.55E+2
F_2	**1.000**	1.000	1.39E+3	0.976	0.961	2.35E+3	**1.000**	1.000	4.93E+2	**1.000**	1.000	9.85E+2	**1.000**	1.000	9.27E+2	0.871	0.804	1.04E+4	**1.000**	1.000	7.61E+2
F_3	**1.000**	1.000	1.11E+3	**1.000**	1.000	4.68E+2	0.980	0.980	1.40E+3	**1.000**	1.000	6.40E+2	**1.000**	1.000	4.94E+2	**1.000**	1.000	9.60E+2	**1.000**	1.000	5.55E+2
F_4	**1.000**	1.000	2.71E+4	0.284	0.000	5.00E+4	0.990	0.961	4.28E+3	0.966	0.863	1.31E+4	**1.000**	1.000	3.73E+3	0.265	0.020	4.90E+4	**1.000**	1.000	7.07E+3
F_5	**1.000**	1.000	5.42E+3	0.971	0.941	4.09E+3	**1.000**	1.000	9.35E+2	**1.000**	1.000	1.56E+3	**1.000**	1.000	1.57E+3	0.853	0.706	1.53E+4	**1.000**	1.000	1.97E+3
F_6	**1.000**	1.000	1.11E+5	0.056	0.000	2.00E+5	0.252	0.000	2.00E+5	0.618	0.000	2.00E+5	0.514	0.000	2.00E+5	0.056	0.000	2.00E+5	0.972	0.647	1.37E+5
F_7	0.877	0.000	2.00E+5	0.054	0.000	2.00E+5	0.400	0.000	2.00E+5	0.546	0.000	2.00E+5	0.876	0.000	2.00E+5	0.053	0.000	2.00E+5	0.884	0.020	1.97E+5
F_8	0.000	0.000	4.00E+5	0.015	0.000	4.00E+5	0.084	0.000	4.00E+5	0.045	0.000	4.00E+5	0.007	0.000	4.00E+5	0.013	0.000	4.00E+5	0.997	0.902	2.35E+5
F_9	0.476	0.000	4.00E+5	0.011	0.000	4.00E+5	0.104	0.000	4.00E+5	0.163	0.000	4.00E+5	0.461	0.000	4.00E+5	0.006	0.000	4.00E+5	0.459	0.000	4.00E+5
F_{10}	**1.000**	1.000	1.96E+4	0.147	0.000	2.00E+5	0.757	0.000	2.00E+5	0.936	0.549	1.17E+5	0.992	0.902	4.27E+4	0.098	0.000	2.00E+5	**1.000**	1.000	8.15E+3
F_{11}	0.660	0.000	2.00E+5	0.314	0.000	2.00E+5	**0.974**	0.843	5.74E+4	0.644	0.000	2.00E+5	0.752	0.078	1.96E+5	0.248	0.000	2.00E+5	0.824	0.255	1.92E+5
F_{12}	0.005	0.000	2.00E+5	0.208	0.000	2.00E+5	0.578	0.000	2.00E+5	0.434	0.000	2.00E+5	0.414	0.000	2.00E+5	0.135	0.000	2.00E+5	0.591	0.000	2.00E+5
F_{13}	0.425	0.000	2.00E+5	0.297	0.000	2.00E+5	**0.797**	0.176	1.71E+5	0.634	0.000	2.00E+5	0.667	0.000	2.00E+5	0.225	0.000	2.00E+5	0.667	0.000	2.00E+5
F_{14}	0.278	0.000	4.00E+5	0.216	0.000	4.00E+5	0.644	0.000	4.00E+5	0.477	0.000	4.00E+5	**0.667**	0.000	4.00E+5	0.190	0.000	4.00E+5	**0.667**	0.000	4.00E+5
F_{15}	0.044	0.000	4.00E+5	0.108	0.000	4.00E+5	0.336	0.000	4.00E+5	0.186	0.000	4.00E+5	0.353	0.000	4.00E+5	0.125	0.000	4.00E+5	0.370	0.000	4.00E+5
F_{16}	0.000	0.000	4.00E+5	0.108	0.000	4.00E+5	0.307	0.000	4.00E+5	0.144	0.000	4.00E+5	**0.667**	0.000	4.00E+5	0.170	0.000	4.00E+5	0.663	0.000	4.00E+5
F_{17}	0.000	0.000	4.00E+5	0.076	0.000	4.00E+5	0.162	0.000	4.00E+5	0.020	0.000	4.00E+5	0.250	0.000	4.00E+5	0.108	0.000	4.00E+5	0.260	0.000	4.00E+5
F_{18}	0.167	0.000	4.00E+5	0.026	0.000	4.00E+5	0.111	0.000	4.00E+5	0.039	0.000	4.00E+5	0.503	0.000	4.00E+5	0.163	0.000	4.00E+5	0.353	0.000	4.00E+5
F_{19}	0.000	0.000	4.00E+5	0.108	0.000	4.00E+5	0.002	0.000	4.00E+5	0.005	0.000	4.00E+5	0.358	0.000	4.00E+5	0.098	0.000	4.00E+5	0.150	0.000	4.00E+5
F_{20}	0.000	0.000	4.00E+5	0.000	0.000	4.00E+5	0.000	0.000	4.00E+5	0.002	0.000	4.00E+5	0.250	0.000	4.00E+5	0.123	0.000	4.00E+5	0.069	0.000	4.00E+5
bprs	7			1			4			4			7			2			7		

F	Self_CSDE			LoICDE			LoISDE			PNPCDE			MOMMOP			LAMC-ACO			LAMS-ACO		
	PR	SR	CS	PR	SR	CS	PR	SR	CS	PR	SR	CS	PR	SR	CS	PR	SR	CS	PR	SR	CS
F_1	**1.000**	1.000	7.15E+2	**1.000**	1.000	1.73E+2	**1.000**	1.000	1.68E+2	**1.000**	1.000	1.62E+2	**1.000**	1.000	1.66E+2	**1.000**	1.000	2.59E+2	**1.000**	1.000	2.14E+2
F_2	**1.000**	1.000	1.03E+3	**1.000**	1.000	1.24E+3	0.486	0.353	3.25E+4	**1.000**	1.000	1.08E+3	**1.000**	1.000	1.09E+3	**1.000**	1.000	5.35E+2	**1.000**	1.000	4.90E+2
F_3	**1.000**	1.000	7.23E+2	**1.000**	1.000	5.84E+2	**1.000**	1.000	7.48E+2	**1.000**	1.000	8.33E+2	**1.000**	1.000	9.58E+2	**1.000**	1.000	3.50E+2	**1.000**	1.000	3.53E+2
F_4	0.907	0.706	2.97E+4	**1.000**	1.000	1.48E+4	0.265	0.020	4.91E+4	**1.000**	1.000	2.28E+4	**1.000**	1.000	3.50E+4	**1.000**	1.000	5.04E+3	**1.000**	1.000	3.50E+3
F_5	**1.000**	1.000	3.38E+3	**1.000**	1.000	1.88E+3	0.814	0.627	1.91E+4	**1.000**	1.000	3.69E+3	**1.000**	1.000	1.48E+4	**1.000**	1.000	1.42E+3	**1.000**	1.000	1.10E+3
F_6	0.760	0.020	1.97E+5	**1.000**	1.000	9.58E+4	0.056	0.000	2.00E+5	0.806	0.157	1.97E+5	**1.000**	1.000	5.61E+4	0.999	0.980	1.10E+5	0.990	0.824	1.05E+5
F_7	0.696	0.000	2.00E+5	0.858	0.020	2.00E+5	0.029	0.000	2.00E+5	0.875	0.000	2.00E+5	**1.000**	1.000	6.32E+4	0.789	0.000	2.00E+5	0.716	0.000	2.00E+5
F_8	0.695	0.000	4.00E+5	0.000	0.000	4.00E+5	0.012	0.000	4.00E+5	0.000	0.000	4.00E+5	**1.000**	1.000	2.85E+5	0.680	0.000	4.00E+5	0.782	0.000	4.00E+5
F_9	0.265	0.000	4.00E+5	0.421	0.000	4.00E+5	0.005	0.000	4.00E+5	0.473	0.000	4.00E+5	**1.000**	1.000	2.95E+5	0.348	0.000	4.00E+5	0.295	0.000	4.00E+5
F_{10}	**1.000**	1.000	1.51E+4	**1.000**	1.000	3.04E+4	0.083	0.000	2.00E+5	**1.000**	1.000	2.16E+4	**1.000**	1.000	4.24E+4	**1.000**	1.000	9.47E+3	**1.000**	1.000	9.02E+3
F_{11}	0.565	0.000	2.00E+5	0.667	0.000	2.00E+5	0.167	0.000	2.00E+5	0.667	0.000	2.00E+5	0.938	0.647	1.73E+5	0.683	0.000	2.00E+5	**0.974**	0.843	1.40E+5
F_{12}	0.409	0.000	2.00E+5	0.615	0.000	2.00E+5	0.125	0.000	2.00E+5	0.015	0.000	2.00E+5	0.949	0.627	1.73E+5	0.824	0.098	1.99E+5	**0.983**	0.863	1.03E+5
F_{13}	0.493	0.000	2.00E+5	0.634	0.000	2.00E+5	0.167	0.000	2.00E+5	0.637	0.000	2.00E+5	0.667	0.000	2.00E+5	0.667	0.000	2.00E+5	0.676	0.000	2.00E+5
F_{14}	0.500	0.000	4.00E+5	0.663	0.000	4.00E+5	0.167	0.000	4.00E+5	0.592	0.000	4.00E+5	**0.667**	0.000	4.00E+5	**0.667**	0.000	4.00E+5	**0.667**	0.000	4.00E+5
F_{15}	0.287	0.000	4.00E+5	0.358	0.000	4.00E+5	0.125	0.000	4.00E+5	0.152	0.000	4.00E+5	0.627	0.000	4.00E+5	0.740	0.000	4.00E+5	**0.748**	0.000	4.00E+5
F_{16}	0.232	0.000	4.00E+5	0.621	0.000	4.00E+5	0.167	0.000	4.00E+5	0.010	0.000	4.00E+5	0.650	0.000	4.00E+5	**0.667**	0.000	4.00E+5	**0.667**	0.000	4.00E+5
F_{17}	0.103	0.000	4.00E+5	0.238	0.000	4.00E+5	0.076	0.000	4.00E+5	0.000	0.000	4.00E+5	0.512	0.000	4.00E+5	0.608	0.000	4.00E+5	**0.708**	0.000	4.00E+5
F_{18}	0.016	0.000	4.00E+5	0.222	0.000	4.00E+5	0.157	0.000	4.00E+5	0.160	0.000	4.00E+5	0.497	0.000	4.00E+5	**0.667**	0.000	4.00E+5	**0.667**	0.000	4.00E+5
F_{19}	0.000	0.000	4.00E+5	0.054	0.000	4.00E+5	0.027	0.000	4.00E+5	0.000	0.000	4.00E+5	0.223	0.000	4.00E+5	0.500	0.000	4.00E+5	**0.502**	0.000	4.00E+5
F_{20}	0.000	0.000	4.00E+5	0.125	0.000	4.00E+5	0.088	0.000	4.00E+5	0.000	0.000	4.00E+5	0.125	0.000	4.00E+5	0.272	0.000	4.00E+5	**0.348**	0.000	4.00E+5
bprs	5			7			2			6			11			9			15		

TABLE SXIV
COMPARISON RESULTS IN PR, SR AND CS BETWEEN LAM-ACOS AND STATE-OF-THE-ART MULTIMODAL METHODS ON TOTAL 20 FUNCTIONS AT ACCURACY LEVEL ε=1.0E-04. THE BEST PR IS HIGHLIGHTED IN BOLD.

	1.0E-04																				
F	CDE			SDE			LIPS			R2PSO			NCDE			NSDE			Self_CCDE		
	PR	SR	CS	PR	SR	CS	PR	SR	CS	PR	SR	CS	PR	SR	CS	PR	SR	CS	PR	SR	CS
F_1	**1.000**	1.000	1.60E+2	0.657	0.373	3.24E+4	0.833	0.686	1.64E+4	**1.000**	1.000	1.88E+2	**1.000**	1.000	6.85E+2	**1.000**	1.000	2.39E+2	**1.000**	1.000	3.55E+2
F_2	**1.000**	1.000	3.23E+3	0.737	0.529	2.39E+4	**1.000**	1.000	7.61E+2	**1.000**	1.000	1.60E+3	**1.000**	1.000	1.64E+3	0.776	0.667	1.74E+4	**1.000**	1.000	1.46E+3
F_3	**1.000**	1.000	3.35E+3	**1.000**	1.000	6.82E+2	0.961	0.961	2.66E+3	**1.000**	1.000	1.17E+3	**1.000**	1.000	9.84E+2	**1.000**	1.000	1.21E+3	**1.000**	1.000	9.55E+2
F_4	**1.000**	1.000	3.93E+4	0.284	0.000	5.00E+4	0.990	0.961	5.00E+3	0.946	0.784	1.82E+4	**1.000**	1.000	4.95E+3	0.240	0.000	5.00E+4	**1.000**	1.000	1.15E+4
F_5	**1.000**	1.000	1.12E+4	0.922	0.843	9.25E+3	**1.000**	1.000	1.49E+3	**1.000**	1.000	2.51E+3	**1.000**	1.000	2.45E+3	0.745	0.490	2.60E+4	**1.000**	1.000	3.66E+3
F_6	**1.000**	1.000	1.38E+5	0.056	0.000	2.00E+5	0.246	0.000	2.00E+5	0.537	0.000	2.00E+5	0.305	0.000	2.00E+5	0.056	0.000	2.00E+5	0.942	0.490	1.65E+5
F_7	0.861	0.000	2.00E+5	0.054	0.000	2.00E+5	0.400	0.000	2.00E+5	0.484	0.000	2.00E+5	0.873	0.000	2.00E+5	0.053	0.000	2.00E+5	0.884	0.020	1.97E+5
F_8	0.000	0.000	4.00E+5	0.015	0.000	4.00E+5	0.084	0.000	4.00E+5	0.023	0.000	4.00E+5	0.001	0.000	4.00E+5	0.013	0.000	4.00E+5	0.994	0.882	2.64E+5
F_9	0.474	0.000	4.00E+5	0.011	0.000	4.00E+5	0.104	0.000	4.00E+5	0.122	0.000	4.00E+5	0.461	0.000	4.00E+5	0.006	0.000	4.00E+5	0.459	0.000	4.00E+5
F_{10}	**1.000**	1.000	2.72E+4	0.147	0.000	2.00E+5	0.748	0.000	2.00E+5	0.905	0.353	1.56E+5	0.989	0.863	5.67E+4	0.098	0.000	2.00E+5	**1.000**	1.000	1.19E+4
F_{11}	0.330	0.000	2.00E+5	0.314	0.000	2.00E+5	**0.974**	0.843	5.90E+4	0.641	0.000	2.00E+5	0.729	0.059	1.97E+5	0.248	0.000	2.00E+5	0.778	0.137	1.97E+5
F_{12}	0.002	0.000	2.00E+5	0.208	0.000	2.00E+5	0.574	0.000	2.00E+5	0.392	0.000	2.00E+5	0.252	0.000	2.00E+5	0.135	0.000	2.00E+5	0.422	0.000	2.00E+5
F_{13}	0.141	0.000	2.00E+5	0.297	0.000	2.00E+5	**0.794**	0.176	1.72E+5	0.627	0.000	2.00E+5	0.667	0.000	2.00E+5	0.225	0.000	2.00E+5	0.660	0.000	2.00E+5
F_{14}	0.026	0.000	4.00E+5	0.216	0.000	4.00E+5	0.644	0.000	4.00E+5	0.408	0.000	4.00E+5	**0.667**	0.000	4.00E+5	0.190	0.000	4.00E+5	0.657	0.000	4.00E+5
F_{15}	0.005	0.000	4.00E+5	0.108	0.000	4.00E+5	0.336	0.000	4.00E+5	0.167	0.000	4.00E+5	0.319	0.000	4.00E+5	0.125	0.000	4.00E+5	0.343	0.000	4.00E+5
F_{16}	0.000	0.000	4.00E+5	0.108	0.000	4.00E+5	0.304	0.000	4.00E+5	0.095	0.000	4.00E+5	**0.667**	0.000	4.00E+5	0.170	0.000	4.00E+5	0.657	0.000	4.00E+5
F_{17}	0.000	0.000	4.00E+5	0.076	0.000	4.00E+5	0.162	0.000	4.00E+5	0.015	0.000	4.00E+5	0.250	0.000	4.00E+5	0.108	0.000	4.00E+5	0.248	0.000	4.00E+5
F_{18}	0.167	0.000	4.00E+5	0.026	0.000	4.00E+5	0.098	0.000	4.00E+5	0.036	0.000	4.00E+5	0.500	0.000	4.00E+5	0.163	0.000	4.00E+5	0.337	0.000	4.00E+5
F_{19}	0.000	0.000	4.00E+5	0.105	0.000	4.00E+5	0.000	0.000	4.00E+5	0.000	0.000	4.00E+5	0.348	0.000	4.00E+5	0.098	0.000	4.00E+5	0.113	0.000	4.00E+5
F_{20}	0.000	0.000	4.00E+5	0.000	0.000	4.00E+5	0.000	0.000	4.00E+5	0.002	0.000	4.00E+5	0.250	0.000	4.00E+5	0.123	0.000	4.00E+5	0.027	0.000	4.00E+5
bprs	7			1			4			4			7			2			6		

F	Self_CSDE			LoICDE			LoISDE			PNPCDE			MOMMOP			LAMC-ACO			LAMS-ACO		
	PR	SR	CS	PR	SR	CS	PR	SR	CS	PR	SR	CS	PR	SR	CS	PR	SR	CS	PR	SR	CS
F_1	**1.000**	1.000	7.15E+2	**1.000**	1.000	1.73E+2	**1.000**	1.000	1.68E+2	**1.000**	1.000	1.62E+2	**1.000**	1.000	1.66E+2	**1.000**	1.000	2.59E+2	**1.000**	1.000	2.14E+2
F_2	**1.000**	1.000	2.34E+3	**1.000**	1.000	3.00E+3	0.235	0.039	4.81E+4	**1.000**	1.000	2.68E+3	**1.000**	1.000	3.09E+3	**1.000**	1.000	7.87E+2	**1.000**	1.000	7.78E+2
F_3	**1.000**	1.000	1.23E+3	**1.000**	1.000	1.52E+3	**1.000**	1.000	1.10E+3	**1.000**	1.000	2.42E+3	**1.000**	1.000	2.47E+3	**1.000**	1.000	5.03E+2	**1.000**	1.000	5.07E+2
F_4	0.686	0.294	4.39E+4	0.975	0.902	2.71E+4	0.250	0.000	5.00E+4	**1.000**	1.000	3.36E+4	**1.000**	1.000	3.69E+4	**1.000**	1.000	6.47E+3	**1.000**	1.000	4.62E+3
F_5	0.961	0.922	1.26E+4	**1.000**	1.000	3.50E+3	0.667	0.333	3.37E+4	**1.000**	1.000	8.97E+3	**1.000**	1.000	1.78E+4	**1.000**	1.000	2.51E+3	**1.000**	1.000	1.83E+3
F_6	0.699	0.020	1.98E+5	**1.000**	1.000	1.20E+5	0.056	0.000	2.00E+5	0.537	0.000	2.00E+5	**1.000**	1.000	5.89E+4	0.999	0.980	1.14E+5	0.990	0.824	1.07E+5
F_7	0.695	0.000	2.00E+5	0.705	0.000	2.00E+5	0.029	0.000	2.00E+5	0.874	0.000	2.00E+5	**1.000**	1.000	7.65E+4	0.743	0.000	2.00E+5	0.683	0.000	2.00E+5
F_8	0.695	0.000	4.00E+5	0.000	0.000	4.00E+5	0.012	0.000	4.00E+5	0.000	0.000	4.00E+5	**1.000**	1.000	3.12E+5	0.639	0.000	4.00E+5	0.765	0.000	4.00E+5
F_9	0.265	0.000	4.00E+5	0.187	0.000	4.00E+5	0.005	0.000	4.00E+5	0.472	0.000	4.00E+5	**1.000**	0.902	3.65E+5	0.290	0.000	4.00E+5	0.254	0.000	4.00E+5
F_{10}	0.992	0.922	3.54E+4	**1.000**	1.000	5.26E+4	0.083	0.000	2.00E+5	**1.000**	1.000	3.45E+4	**1.000**	1.000	4.40E+4	**1.000**	1.000	1.13E+4	**1.000**	1.000	1.08E+4
F_{11}	0.399	0.000	2.00E+5	0.660	0.000	2.00E+5	0.167	0.000	2.00E+5	0.660	0.000	2.00E+5	0.716	0.020	1.98E+5	0.670	0.000	2.00E+5	0.961	0.765	1.49E+5
F_{12}	0.321	0.000	2.00E+5	0.495	0.000	2.00E+5	0.125	0.000	2.00E+5	0.000	0.000	2.00E+5	0.939	0.549	1.84E+5	0.770	0.000	2.00E+5	**0.983**	0.863	1.09E+5
F_{13}	0.317	0.000	2.00E+5	0.510	0.000	2.00E+5	0.167	0.000	2.00E+5	0.461	0.000	2.00E+5	0.667	0.000	2.00E+5	0.667	0.000	2.00E+5	0.670	0.000	2.00E+5
F_{14}	0.304	0.000	4.00E+5	0.657	0.000	4.00E+5	0.167	0.000	4.00E+5	0.258	0.000	4.00E+5	**0.667**	0.000	4.00E+5	**0.667**	0.000	4.00E+5	**0.667**	0.000	4.00E+5
F_{15}	0.186	0.000	4.00E+5	0.299	0.000	4.00E+5	0.125	0.000	4.00E+5	0.015	0.000	4.00E+5	0.618	0.000	4.00E+5	0.740	0.000	4.00E+5	**0.748**	0.000	4.00E+5
F_{16}	0.072	0.000	4.00E+5	0.559	0.000	4.00E+5	0.167	0.000	4.00E+5	0.000	0.000	4.00E+5	0.650	0.000	4.00E+5	**0.667**	0.000	4.00E+5	**0.667**	0.000	4.00E+5
F_{17}	0.056	0.000	4.00E+5	0.233	0.000	4.00E+5	0.076	0.000	4.00E+5	0.000	0.000	4.00E+5	0.505	0.000	4.00E+5	0.608	0.000	4.00E+5	**0.708**	0.000	4.00E+5
F_{18}	0.003	0.000	4.00E+5	0.219	0.000	4.00E+5	0.157	0.000	4.00E+5	0.147	0.000	4.00E+5	0.497	0.000	4.00E+5	**0.667**	0.000	4.00E+5	**0.667**	0.000	4.00E+5
F_{19}	0.000	0.000	4.00E+5	0.037	0.000	4.00E+5	0.027	0.000	4.00E+5	0.000	0.000	4.00E+5	0.223	0.000	4.00E+5	0.500	0.000	4.00E+5	**0.502**	0.000	4.00E+5
F_{20}	0.000	0.000	4.00E+5	0.123	0.000	4.00E+5	0.088	0.000	4.00E+5	0.000	0.000	4.00E+5	0.125	0.000	4.00E+5	0.267	0.000	4.00E+5	**0.346**	0.000	4.00E+5
bprs	3			6			2			6			11			9			14		

TABLE SXV
COMPARISON RESULTS IN PR, SR AND CS BETWEEN LAM-ACOS AND STATE-OF-THE-ART MULTIMODAL METHODS ON TOTAL 20 FUNCTIONS AT ACCURACY LEVEL ε=1.0E-05. THE BEST PR IS HIGHLIGHTED IN BOLD

1.0E-05																					
F	CDE			SDE			LIPS			R2PSO			NCDE			NSDE			Self_CCDE		
	PR	SR	CS	PR	SR	CS	PR	SR	CS	PR	SR	CS	PR	SR	CS	PR	SR	CS	PR	SR	CS
F_1	**1.000**	1.000	1.60E+2	0.657	0.373	3.24E+4	0.833	0.686	1.64E+4	**1.000**	1.000	1.88E+2	**1.000**	1.000	6.85E+2	**1.000**	1.000	2.39E+2	**1.000**	1.000	3.55E+2
F_2	**1.000**	1.000	6.68E+3	0.584	0.275	3.65E+4	**1.000**	1.000	1.36E+3	**1.000**	1.000	2.41E+3	**1.000**	1.000	2.52E+3	0.753	0.627	1.95E+4	**1.000**	1.000	2.35E+3
F_3	**1.000**	1.000	7.93E+3	**1.000**	1.000	8.33E+2	0.961	0.961	3.04E+3	**1.000**	1.000	1.73E+3	**1.000**	1.000	1.80E+3	**1.000**	1.000	1.82E+3	**1.000**	1.000	1.94E+3
F_4	0.755	0.431	4.87E+4	0.284	0.000	5.00E+4	0.990	0.961	5.66E+3	0.907	0.627	2.51E+4	**1.000**	1.000	6.03E+3	0.235	0.000	5.00E+4	0.990	0.961	1.76E+4
F_5	**1.000**	1.000	1.93E+4	0.853	0.706	1.62E+4	**1.000**	1.000	2.18E+3	**1.000**	1.000	3.52E+3	**1.000**	1.000	3.42E+3	0.608	0.235	3.85E+4	**1.000**	1.000	6.97E+3
F_6	0.997	0.961	1.65E+5	0.056	0.000	2.00E+5	0.244	0.000	2.00E+5	0.461	0.000	2.00E+5	0.158	0.000	2.00E+5	0.053	0.000	2.00E+5	0.923	0.373	1.82E+5
F_7	0.699	0.000	2.00E+5	0.054	0.000	2.00E+5	0.397	0.000	2.00E+5	0.427	0.000	2.00E+5	0.870	0.000	2.00E+5	0.053	0.000	2.00E+5	0.884	0.020	1.97E+5
F_8	0.000	0.000	4.00E+5	0.015	0.000	4.00E+5	0.084	0.000	4.00E+5	0.011	0.000	4.00E+5	0.000	0.000	4.00E+5	0.013	0.000	4.00E+5	0.993	0.843	2.81E+5
F_9	0.397	0.000	4.00E+5	0.011	0.000	4.00E+5	0.103	0.000	4.00E+5	0.085	0.000	4.00E+5	0.460	0.000	4.00E+5	0.006	0.000	4.00E+5	0.459	0.000	4.00E+5
F_{10}	**1.000**	1.000	3.57E+4	0.147	0.000	2.00E+5	0.747	0.000	2.00E+5	0.843	0.118	1.84E+5	0.984	0.804	7.13E+4	0.098	0.000	2.00E+5	**1.000**	1.000	1.62E+4
F_{11}	0.085	0.000	2.00E+5	0.314	0.000	2.00E+5	**0.974**	0.843	6.10E+4	0.627	0.000	2.00E+5	0.703	0.039	1.97E+5	0.248	0.000	2.00E+5	0.752	0.078	1.98E+5
F_{12}	0.000	0.000	2.00E+5	0.208	0.000	2.00E+5	0.574	0.000	2.00E+5	0.353	0.000	2.00E+5	0.179	0.000	2.00E+5	0.135	0.000	2.00E+5	0.314	0.000	2.00E+5
F_{13}	0.020	0.000	2.00E+5	0.297	0.000	2.00E+5	**0.794**	0.176	1.72E+5	0.611	0.000	2.00E+5	0.660	0.000	2.00E+5	0.225	0.000	2.00E+5	0.647	0.000	2.00E+5
F_{14}	0.007	0.000	4.00E+5	0.216	0.000	4.00E+5	0.644	0.000	4.00E+5	0.369	0.000	4.00E+5	**0.667**	0.000	4.00E+5	0.190	0.000	4.00E+5	0.641	0.000	4.00E+5
F_{15}	0.000	0.000	4.00E+5	0.108	0.000	4.00E+5	0.336	0.000	4.00E+5	0.150	0.000	4.00E+5	0.306	0.000	4.00E+5	0.125	0.000	4.00E+5	0.309	0.000	4.00E+5
F_{16}	0.000	0.000	4.00E+5	0.108	0.000	4.00E+5	0.304	0.000	4.00E+5	0.082	0.000	4.00E+5	**0.667**	0.000	4.00E+5	0.170	0.000	4.00E+5	0.641	0.000	4.00E+5
F_{17}	0.000	0.000	4.00E+5	0.076	0.000	4.00E+5	0.162	0.000	4.00E+5	0.010	0.000	4.00E+5	0.250	0.000	4.00E+5	0.108	0.000	4.00E+5	0.248	0.000	4.00E+5
F_{18}	0.167	0.000	4.00E+5	0.026	0.000	4.00E+5	0.095	0.000	4.00E+5	0.033	0.000	4.00E+5	0.493	0.000	4.00E+5	0.163	0.000	4.00E+5	0.324	0.000	4.00E+5
F_{19}	0.000	0.000	4.00E+5	0.105	0.000	4.00E+5	0.000	0.000	4.00E+5	0.000	0.000	4.00E+5	0.331	0.000	4.00E+5	0.098	0.000	4.00E+5	0.059	0.000	4.00E+5
F_{20}	0.000	0.000	4.00E+5	0.000	0.000	4.00E+5	0.000	0.000	4.00E+5	0.000	0.000	4.00E+5	0.250	0.000	4.00E+5	0.123	0.000	4.00E+5	0.002	0.000	4.00E+5
bprs	5			1			4			4			7			2			5		
F	Self_CSDE			LoICDE			LoISDE			PNPCDE			MOMMOP			LAMC-ACO			LAMS-ACO		
	PR	SR	CS	PR	SR	CS	PR	SR	CS	PR	SR	CS	PR	SR	CS	PR	SR	CS	PR	SR	CS
F_1	**1.000**	1.000	7.15E+2	**1.000**	1.000	1.73E+2	**1.000**	1.000	1.68E+2	**1.000**	1.000	1.62E+2	**1.000**	1.000	1.66E+2	**1.000**	1.000	2.59E+2	**1.000**	1.000	2.14E+2
F_2	0.992	0.961	8.36E+3	**1.000**	1.000	6.50E+3	0.204	0.000	5.00E+4	**1.000**	1.000	6.60E+3	**1.000**	1.000	5.78E+3	**1.000**	1.000	1.04E+3	**1.000**	1.000	1.07E+3
F_3	0.980	0.980	4.38E+3	**1.000**	1.000	3.74E+3	**1.000**	1.000	1.50E+3	**1.000**	1.000	5.37E+3	**1.000**	1.000	5.06E+3	**1.000**	1.000	6.06E+2	**1.000**	1.000	6.54E+2
F_4	0.505	0.059	4.88E+4	0.902	0.647	3.77E+4	0.250	0.000	5.00E+4	0.971	0.882	4.41E+4	0.980	0.922	3.92E+4	**1.000**	1.000	7.66E+3	**1.000**	1.000	5.45E+3
F_5	0.667	0.471	3.45E+4	**1.000**	1.000	5.65E+3	0.529	0.059	4.71E+4	**1.000**	1.000	1.60E+4	**1.000**	1.000	1.87E+4	**1.000**	1.000	3.76E+3	**1.000**	1.000	2.59E+3
F_6	0.635	0.020	1.98E+5	**1.000**	1.000	1.43E+5	0.056	0.000	2.00E+5	0.244	0.000	2.00E+5	**1.000**	1.000	6.18E+4	0.999	0.980	1.17E+5	0.990	0.824	1.09E+5
F_7	0.694	0.000	2.00E+5	0.433	0.000	2.00E+5	0.029	0.000	2.00E+5	0.855	0.000	2.00E+5	**1.000**	1.000	9.07E+4	0.714	0.000	2.00E+5	0.660	0.000	2.00E+5
F_8	0.694	0.000	4.00E+5	0.000	0.000	4.00E+5	0.012	0.000	4.00E+5	0.000	0.000	4.00E+5	**1.000**	1.000	3.36E+5	0.403	0.000	4.00E+5	0.647	0.000	4.00E+5
F_9	0.265	0.000	4.00E+5	0.028	0.000	4.00E+5	0.005	0.000	4.00E+5	0.466	0.000	4.00E+5	**0.979**	0.039	4.00E+5	0.256	0.000	4.00E+5	0.235	0.000	4.00E+5
F_{10}	0.967	0.784	7.39E+4	**1.000**	1.000	8.03E+4	0.083	0.000	2.00E+5	**1.000**	1.000	4.74E+4	**1.000**	1.000	4.55E+4	**1.000**	1.000	1.27E+4	**1.000**	1.000	1.21E+4
F_{11}	0.281	0.000	2.00E+5	0.611	0.000	2.00E+5	0.167	0.000	2.00E+5	0.415	0.000	2.00E+5	0.673	0.000	2.00E+5	0.670	0.000	2.00E+5	0.944	0.667	1.63E+5
F_{12}	0.223	0.000	2.00E+5	0.341	0.000	2.00E+5	0.125	0.000	2.00E+5	0.000	0.000	2.00E+5	0.828	0.098	1.99E+5	0.750	0.000	2.00E+5	**0.980**	0.843	1.18E+5
F_{13}	0.176	0.000	2.00E+5	0.373	0.000	2.00E+5	0.167	0.000	2.00E+5	0.157	0.000	2.00E+5	0.667	0.000	2.00E+5	0.667	0.000	2.00E+5	0.667	0.000	2.00E+5
F_{14}	0.160	0.000	4.00E+5	0.647	0.000	4.00E+5	0.167	0.000	4.00E+5	0.059	0.000	4.00E+5	**0.667**	0.000	4.00E+5	**0.667**	0.000	4.00E+5	**0.667**	0.000	4.00E+5
F_{15}	0.113	0.000	4.00E+5	0.275	0.000	4.00E+5	0.125	0.000	4.00E+5	0.002	0.000	4.00E+5	0.613	0.000	4.00E+5	0.730	0.000	4.00E+5	**0.748**	0.000	4.00E+5
F_{16}	0.026	0.000	4.00E+5	0.490	0.000	4.00E+5	0.167	0.000	4.00E+5	0.000	0.000	4.00E+5	0.650	0.000	4.00E+5	**0.667**	0.000	4.00E+5	**0.667**	0.000	4.00E+5
F_{17}	0.015	0.000	4.00E+5	0.233	0.000	4.00E+5	0.076	0.000	4.00E+5	0.000	0.000	4.00E+5	0.475	0.000	4.00E+5	0.505	0.000	4.00E+5	**0.625**	0.000	4.00E+5
F_{18}	0.000	0.000	4.00E+5	0.219	0.000	4.00E+5	0.157	0.000	4.00E+5	0.098	0.000	4.00E+5	0.497	0.000	4.00E+5	**0.667**	0.000	4.00E+5	**0.667**	0.000	4.00E+5
F_{19}	0.000	0.000	4.00E+5	0.025	0.000	4.00E+5	0.027	0.000	4.00E+5	0.000	0.000	4.00E+5	0.223	0.000	4.00E+5	0.498	0.000	4.00E+5	**0.502**	0.000	4.00E+5
F_{20}	0.000	0.000	4.00E+5	0.123	0.000	4.00E+5	0.088	0.000	4.00E+5	0.000	0.000	4.00E+5	0.125	0.000	4.00E+5	0.245	0.000	4.00E+5	**0.333**	0.000	4.00E+5
bprs	1			6			2			5			10			9			14		

TABLE SXVI
THE CHANGE OF 'BRPS" OF DIFFERENT ALGORITHMS WITH THE ACCURACY LEVEL INCREASING.

Accuracy Level / Algorithm / bprs	$\varepsilon = 1.0E-01$	$\varepsilon = 1.0E-02$	$\varepsilon = 1.0E-03$	$\varepsilon = 1.0E-04$	$\varepsilon = 1.0E-05$
CDE	12	7	7	7	5
SDE	5	4	1	1	1
LIPS	6	4	4	4	4
R2PSO	8	5	4	4	4
NCDE	14	6	7	7	7
NSDE	8	2	2	2	2
Self_CCDE	12	7	7	6	5
Self_CSDE	7	6	5	3	1
LoICDE	15	7	7	6	6
LoISDE	8	4	2	2	2
PNPCDE	13	6	6	6	5
MOMMOP	17	13	11	11	10
LAMC-ACO	15	9	9	9	9
LAMS-ACO	11	12	15	14	14

TABLE SXVII
COMPARISON RESULTS WITH RESPECT TO CS ON FIVE FUNCTIONS (F_1-F_5) AT THE FIVE ACCURACY LEVELS. EACH UNIT HAS TWO NUMBERS IN FORM OF "NUMBER1/NUMBER2" WITH "NUMBER1" INDICATING THE NUMBER OF FUNCTIONS WHERE LAMC-ACO ACHIEVES A SMALLER CS THAN THE COMPARED METHOD AND "NUMBER2" SUGGESTING THE NUMBER OF FUNCTIONS WHERE LSMS-ACO ACHIEVES A SMALLER CS.

Accuracy Level / Algorithm		$\varepsilon = 1.0E-02$	$\varepsilon = 1.0E-03$	$\varepsilon = 1.0E-04$	$\varepsilon = 1.0E-05$
CDE	3 / 3	4 / 4	4 / 4	4 / 4	4 / 4
NCDE	4/ 3	3 / 5	4 / 5	3 / 5	3 / 5
Self_CCDE	4 / 4	4 / 5	5 / 5	5 / 5	5 / 5
LoICDE	2 / 2	3 / 4	4 / 4	4 / 4	4 / 4
PNPCDE	3/ 2	4 / 4	4 / 4	4 / 4	4 / 4
MOMMOP	3 / 3	4 / 4	4 / 4	4 / 4	4 / 4

∗ In the following five tables (Tables SXVIII-SXXII), nonparametric Wilcoxon Rank-Sum test results with respect to PR between LAM-ACOs and the compared methods are presented with each table associated with one accuracy level. Each compared algorithm is associated with two columns, of which the left one is the results compared with LAMC-ACO and the right one is the results compared with LAMS-ACO. The grayed units mean LAMC-ACO or LAMS-ACO is significantly better than the compared algorithm, while the bolded values indicate that LAMC-ACO or LAMS-ACO is significantly worse. The other cases suggest LAMC-ACO or LAMS-ACO performs similarly to the compared method. The last row (*w/t/l*) of these tables counts the number of functions on which LAMC-ACO or LAMS-ACO significantly wins, ties and significantly loses the competitions when compared with corresponding counterparts, respectively. Table SXXIII presents the change of "*w/t/l*" of LAMC-ACO and LAMS-ACO compared with the counterparts with the left associated with LAMC-ACO and the right related to LAMS-ACO.

TABLE SXVIII

WILCOXON RANK SUM TEST RESULTS BETWEEN LAM-ACOS AND STATE-OF-THE-ART METHODS AT ACCURACY LEVEL ε=1.0E-01.

	1.0E-01																							
F	CDE		SDE		LIPS		R2PSO		NCDE		NSDE		Self_CCDE		Self_CSDE		LoICDE		LoISDE		PNPCDE		MOMMOP	
F_1	2627	2627	3443	3443	3035	3035	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627
F_2	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627
F_3	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627
F_4	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627
F_5	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2652	2652	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627
F_6	2601	2448	3927	3927	3927	3927	3926	3920	3582	3498	3927	3927	2652	2499	3689	3635	2601	2448	3927	3927	2601	2448	2601	2448
F_7	2627	2627	2627	2627	2678	2678	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627
F_8	3927	3927	3927	3927	3927	3927	3927	3927	3737	3886	3927	3927	**1326**	**1326**	2931	3553	3927	3927	3927	3927	3927	3927	**1326**	**1326**
F_9	**1336**	**1326**	3927	3927	3927	3927	3927	3927	**1408**	**1326**	3927	3927	**1366**	**1327**	3902	3706	**1359**	**1326**	3927	3927	**1366**	**1326**	**1326**	**1326**
F_{10}	2627	2627	3800	3800	3647	3647	2856	2856	2627	2627	3927	3927	2627	2627	2627	2627	2627	2627	3927	3927	2627	2627	2627	2627
F_{11}	2627	2627	2729	2729	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2652	2652	2627	2627	2678	2678	2627	2627	2627	2627
F_{12}	3927	3927	3927	3927	3927	3927	3927	3921	2907	2760	3927	3927	3035	2882	3774	3735	3927	3924	3927	3927	3927	3927	2882	2729
F_{13}	2601	2601	3303	3303	2929	2929	2626	2626	3083	3083	3277	3277	2627	2627	3186	3186	2678	2678	3667	3667	2601	2601	2601	2601
F_{14}	2627	2627	2729	2729	2652	2652	2627	2627	2627	2627	2652	2652	2627	2627	2652	2652	2627	2627	2652	2652	2627	2627	2627	2627
F_{15}	2652	2627	3213	3199	3494	3485	3035	3017	2627	2601	2627	2601	2627	2601	3723	3716	2627	2601	2627	2601	2627	2601	3621	3608
F_{16}	3876	3876	3086	3086	2627	2627	3188	3188	2627	2627	2627	2627	2627	2627	2652	2652	2627	2627	2627	2627	3060	3060	2627	2627
F_{17}	3927	3927	3188	3159	3774	3768	3876	3874	2627	2576	2805	2761	2729	2681	3825	3819	2627	2576	3137	3106	3927	3927	2627	2576
F_{18}	2627	2627	3723	3723	2984	2984	3519	3519	2627	2627	2652	2652	2627	2627	3290	3290	2627	2627	2703	2703	2627	2627	2627	2627
F_{19}	3927	3927	3868	3865	3927	3927	3927	3927	2806	2749	3927	3927	3757	3743	3927	3927	3927	3927	3898	3896	3927	3927	3927	3927
F_{20}	3927	3927	3927	3927	3927	3927	3871	3882	**2015**	**1913**	**2052**	**1952**	2990	2965	3927	3927	**2015**	**1913**	2652	2584	3927	3927	**2015**	**1913**
w/t/l	6/13/1	6/13/1	13/7/0	13/7/0	12/8/0	12/8/0	10/10/0	10/10/0	4/14/2	3/15/2	7/12/1	7/12/1	3/15/2	3/15/2	10/10/0	10/10/0	3/15/2	3/15/2	8/12/0	8/12/0	6/13/1	6/13/1	3/14/3	2/15/3

TABLE SXIX

WILCOXON RANK SUM TEST RESULTS BETWEEN LAM-ACOS AND STATE-OF-THE-ART METHODS AT ACCURACY LEVEL ε=1.0E-02.

	1.0E-02																							
F	CDE		SDE		LIPS		R2PSO		NCDE		NSDE		Self_CCDE		Self_CSDE		LoICDE		LoISDE		PNPCDE		MOMMOP	
F_1	2627	2627	3443	3443	3035	3035	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627
F_2	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2678	2678	2627	2627	2627	2627	2627	2627	2882	2882	2627	2627	2627	2627
F_3	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627
F_4	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2652	2652	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627
F_5	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2754	2754	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627
F_6	2601	2448	3927	3927	3927	3927	3927	3924	3926	3917	3927	3927	2805	2652	3818	3773	2601	2448	3927	3927	2964	2847	2601	2448
F_7	**1960**	**1428**	3927	3927	3927	3927	3924	3871	**1976**	**1444**	3927	3927	**1912**	**1426**	3695	3295	**1909**	**1397**	3927	3927	**1962**	**1450**	**1326**	**1326**
F_8	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	**1326**	**1326**	2449	3484	3927	3927	3927	3927	3927	3927	**1326**	**1326**
F_9	**1347**	**1326**	3927	3927	3927	3927	3927	3927	**1389**	**1326**	3927	3927	**1417**	**1327**	3878	3618	**1347**	**1326**	3927	3927	**1364**	**1326**	**1326**	**1326**
F_{10}	2627	2627	3927	3927	3902	3902	3086	3086	2729	2729	3927	3927	2627	2627	2627	2627	2627	2627	3927	3927	2627	2627	2627	2627
F_{11}	3851	3927	3927	3927	**2003**	2703	3858	3927	2931	3544	3927	3927	**2243**	2958	3615	3823	3851	3927	3927	3927	3851	3927	**1835**	2525
F_{12}	3927	3927	3927	3927	3927	3927	3927	3927	3729	3722	3927	3927	3575	3563	3921	3920	3927	3927	3927	3927	3927	3927	2780	2754
F_{13}	2754	2938	3927	3927	**1785**	**1949**	2703	2895	2627	2831	3927	3927	2627	2831	2958	3110	2627	2831	3927	3927	2627	2831	**1326**	**1378**
F_{14}	3035	3035	3927	3927	2805	2805	3417	3417	2627	2627	3927	3927	2627	2627	2907	2907	2627	2627	3927	3927	2678	2678	**2295**	**2295**
F_{15}	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3896	3900	3927	3927	3925	3927	3406	3472
F_{16}	3927	3927	3927	3927	3927	3927	3927	3927	2627	2627	3927	3927	2627	2627	3749	3749	2703	2703	3927	3927	3902	3902	2754	2754
F_{17}	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3914	3926	3927	3927	3927	3927	3927	3927	3927	3927	3295	3766
F_{18}	3927	3927	3927	3927	3927	3927	3927	3927	3570	3570	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927
F_{19}	3927	3927	3927	3927	3927	3927	3927	3927	3621	3652	3927	3927	3921	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927
F_{20}	3927	3927	3927	3927	3927	3927	3927	3927	2856	3545	3927	3927	3675	3837	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927
w/t/l	10/8/2	11/7/2	16/4/0	16/4/0	13/5/2	13/6/1	14/6/0	15/5/0	8/10/2	9/9/2	15/5/0	15/5/0	6/10/4	7/10/3	13/7/0	14/6/0	8/10/2	8/10/2	16/4/0	16/4/0	10/8/2	9/9/2	5/9/6	5/10/5

TABLE SXX

WILCOXON RANK SUM TEST RESULTS BETWEEN LAM-ACOS AND STATE-OF-THE-ART METHODS AT ACCURACY LEVEL ε=1.0E-03.

1.0E-03																								
F	CDE		SDE		LIPS		R2PSO		NCDE		NSDE		Self_CCDE		Self_CSDE		LoICDE		LoISDE		PNPCDE		MOMMOP	
F_1	2627	2627	3443	3443	3035	3035	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627
F_2	2627	2627	2678	2678	2627	2627	2627	2627	2627	2627	2882	2882	2627	2627	2627	2627	2627	2627	3468	3468	2627	2627	2627	2627
F_3	2627	2627	2627	2627	2652	2652	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627
F_4	2627	2627	3927	3927	2678	2678	2805	2805	2627	2627	3902	3902	2627	2627	3009	3009	2627	2627	3902	3902	2627	2627	2627	2627
F_5	2627	2627	2703	2703	2627	2627	2627	2627	2627	2627	3009	3009	2627	2627	2627	2627	2627	2627	3111	3111	2627	2627	2627	2627
F_6	2601	2397	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3063	2883	3897	3861	2601	2397	3927	3927	3717	3665	2601	2397
F_7	**1610**	**1349**	3927	3927	3927	3927	3925	3875	**1638**	**1358**	3927	3927	**1590**	**1348**	3479	2907	**1762**	**1373**	3927	3927	**1629**	**1365**	**1326**	**1326**
F_8	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	**1326**	**1326**	**2273**	3409	3927	3927	3927	3927	3927	3927	**1326**	**1326**
F_9	**1326**	**1326**	3927	3927	3927	3927	3927	3927	**1326**	**1326**	3927	3927	**1326**	**1326**	3697	3176	**1354**	**1326**	3927	3927	**1326**	**1326**	**1326**	**1326**
F_{10}	2627	2627	3927	3927	3927	3927	3213	3213	2754	2754	3927	3927	2627	2627	2627	2627	2627	2627	3927	3927	2627	2627	2627	2627
F_{11}	2800	3927	3927	3927	**1346**	2627	2915	3927	**2183**	3737	3927	3927	**1829**	3456	3301	3919	2754	3927	3927	3927	2754	3927	**1397**	2886
F_{12}	3927	3927	3927	3927	3797	3927	3914	3927	3901	3927	3927	3927	3679	3913	3865	3924	3810	3927	3927	3927	3927	3927	**1737**	2940
F_{13}	3723	3735	3927	3927	**1836**	**1896**	2882	2943	2627	2703	3927	3927	2627	2703	3468	3495	2882	2943	3927	3927	2831	2895	2627	2703
F_{14}	3851	3851	3927	3927	2805	2805	3698	3698	2627	2627	3927	3927	2627	2627	3570	3570	2652	2652	3927	3927	3035	3035	2627	2627
F_{15}	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3923	3926	3927	3927	3927	3927	3467	3525
F_{16}	3927	3927	3927	3927	3927	3927	3927	3927	2627	2627	3927	3927	2652	2652	3876	3876	2958	2958	3927	3927	3927	3927	2754	2754
F_{17}	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3925	3927	3927	3927	3927	3927	3927	3927	3927	3927	3287	3774
F_{18}	3927	3927	3927	3927	3927	3927	3927	3927	3621	3621	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927
F_{19}	3927	3927	3927	3927	3927	3927	3927	3927	3624	3652	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927
F_{20}	3927	3927	3927	3927	3927	3927	3927	3927	2856	3545	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927
w/t/l	10/8/2	11/7/2	17/3/0	17/3/0	13/5/2	13/6/1	15/5/0	15/5/0	7/10/3	9/9/2	18/2/0	18/2/0	7/9/4	8/9/3	14/5/1	15/5/0	9/9/2	10/8/2	18/2/0	18/2/0	10/8/2	12/6/2	5/10/5	7/10/3

TABLE SXXI

WILCOXON RANK SUM TEST RESULTS BETWEEN LAM-ACOS AND STATE-OF-THE-ART METHODS AT ACCURACY LEVEL ε=1.0E-04.

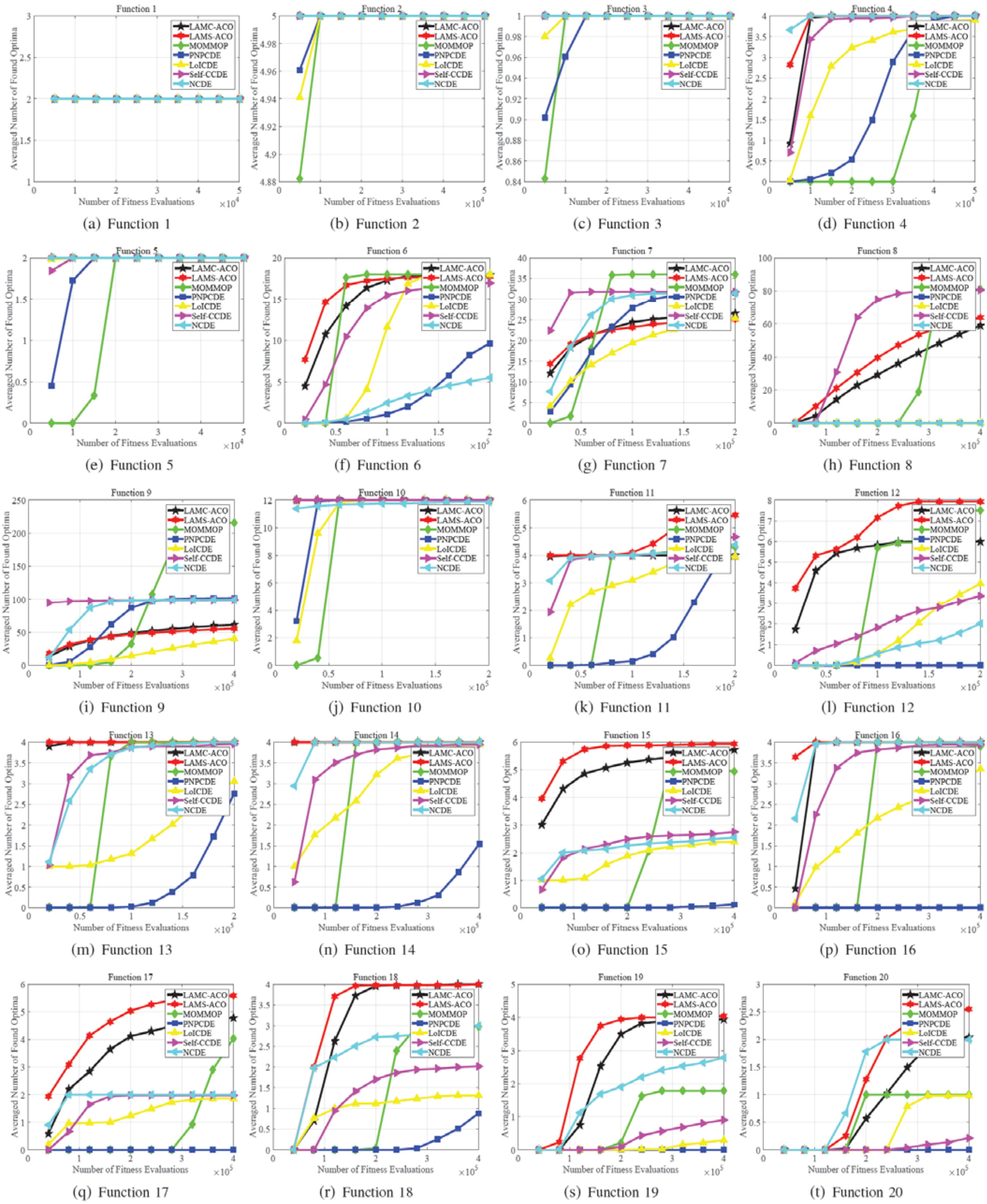
1.0E-04																								
F	CDE		SDE		LIPS		R2PSO		NCDE		NSDE		Self_CCDE		Self_CSDE		LoICDE		LoISDE		PNPCDE		MOMMOP	
F_1	2627	2627	3443	3443	3035	3035	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627
F_2	2627	2627	3239	3239	2627	2627	2627	2627	2627	2627	3060	3060	2627	2627	2627	2627	2627	2627	3876	3876	2627	2627	2627	2627
F_3	2627	2627	2627	2627	2678	2678	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627
F_4	2627	2627	3927	3927	2678	2678	2907	2907	2627	2627	3927	3927	2627	2627	3545	3545	2754	2754	3927	3927	2627	2627	2627	2627
F_5	2627	2627	2831	2831	2627	2627	2627	2627	2627	2627	3290	3290	2627	2627	2729	2729	2627	2627	3494	3494	2627	2627	2627	2627
F_6	2601	2397	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3272	3132	3898	3866	2601	2397	3927	3927	3927	3923	2601	2397
F_7	**1396**	**1331**	3927	3927	3927	3927	3927	3924	**1390**	**1334**	3927	3927	**1366**	**1330**	3176	2537	3061	**2334**	3927	3927	**1390**	**1338**	**1326**	**1326**
F_8	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	**1326**	**1326**	**1977**	3260	3927	3927	3927	3927	3927	3927	**1326**	**1326**
F_9	**1326**	**1326**	3927	3927	3927	3927	3927	3927	**1326**	**1326**	3927	3927	**1326**	**1326**	3076	2425	3927	3911	3927	3927	**1326**	**1326**	**1326**	**1326**
F_{10}	2627	2627	3927	3927	3927	3927	3468	3468	2805	2805	3927	3927	2627	2627	2729	2729	2627	2627	3927	3927	2627	2627	2627	2627
F_{11}	3827	3927	3927	3927	**1330**	2525	2852	3927	**2243**	3755	3927	3927	**1960**	3587	3802	3927	2702	3927	3927	3927	2702	3927	**2295**	3818
F_{12}	3927	3927	3927	3927	3734	3927	3927	3927	3927	3927	3927	3927	3927	3927	3906	3927	3927	3927	3927	3927	3927	3927	**1469**	3042
F_{13}	3927	3927	3927	3927	**1862**	**1881**	2933	2952	2627	2652	3927	3927	2678	2702	3902	3902	3494	3502	3927	3927	3545	3552	2627	2652
F_{14}	3927	3927	3927	3927	2805	2805	3800	3800	2627	2627	3927	3927	2703	2703	3876	3876	2703	2703	3927	3927	3723	3723	2627	2627
F_{15}	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3471	3526
F_{16}	3927	3927	3927	3927	3927	3927	3927	3927	2627	2627	3927	3927	2703	2703	3927	3927	3417	3417	3927	3927	3927	3927	2754	2754
F_{17}	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3335	3790
F_{18}	3927	3927	3927	3927	3927	3927	3927	3927	3647	3647	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927
F_{19}	3927	3927	3927	3927	3927	3927	3927	3927	3675	3702	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927
F_{20}	3927	3927	3927	3927	3927	3927	3927	3927	2805	3519	3902	3927	3922	3927	3927	3927	3902	3927	3909	3927	3927	3927	3902	3927
w/t/l	11/7/2	11/7/2	18/2/0	18/2/0	13/5/2	13/6/1	15/5/0	16/4/0	7/10/3	9/9/2	18/2/0	18/2/0	7/9/4	8/9/3	14/5/1	13/7/0	11/9/0	11/8/1	18/2/0	18/2/0	11/7/2	12/6/2	5/10/5	7/10/3

TABLE SXXII
WILCOXON RANK SUM TEST RESULTS BETWEEN LAM-ACOS AND STATE-OF-THE-ART METHODS AT ACCURACY LEVEL ε=1.0E-05.

1.0E-05																								
F	CDE		SDE		LIPS		R2PSO		NCDE		NSDE		Self_CCDE		Self_CSDE		LoICDE		LoISDE		PNPCDE		MOMMOP	
F_1	2627	2627	3443	3443	3035	3035	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627	2627
F_2	2627	2627	3570	3570	2627	2627	2627	2627	2627	2627	3111	3111	2627	2627	2678	2678	2627	2627	3927	3927	2627	2627	2627	2627
F_3	2627	2627	2627	2627	2678	2678	2627	2627	2627	2627	2627	2627	2627	2627	2652	2652	2627	2627	2627	2627	2627	2627	2627	2627
F_4	3366	3366	3927	3927	2678	2678	3111	3111	2627	2627	3927	3927	2678	2678	3851	3851	3086	3086	3927	3927	2780	2780	2729	2729
F_5	2627	2627	3009	3009	2627	2627	2627	2627	2627	2627	3621	3621	2627	2627	3315	3315	2627	2627	3851	3851	2627	2627	2627	2627
F_6	2653	2453	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3428	3308	3899	3875	2601	2397	3927	3927	3927	3927	2601	2397
F_7	2766	**2192**	3927	3927	3927	3927	3927	3927	**1353**	**1332**	3927	3927	**1339**	**1329**	2889	**2290**	3927	3916	3927	3927	**1393**	**1343**	**1326**	**1326**
F_8	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	**1326**	**1326**	**1378**	**2083**	3927	3927	3927	3927	3927	3927	**1326**	**1326**
F_9	**1326**	**1326**	3927	3927	3927	3927	3927	3927	**1326**	**1326**	3927	3927	**1326**	**1326**	2463	**2162**	3927	3927	3927	3927	**1326**	**1326**	**1326**	**1326**
F_{10}	2627	2627	3927	3927	3927	3927	3774	3774	2882	2882	3927	3927	2627	2627	2907	2907	2627	2627	3927	3927	2627	2627	2627	2627
F_{11}	3927	3927	3927	3927	**1330**	2397	2952	3927	2422	3800	3927	3927	**2089**	3638	3902	3927	3077	3927	3927	3927	3702	3927	2601	3910
F_{12}	3927	3927	3927	3927	3698	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	**1938**	3684
F_{13}	3927	3927	3927	3927	**1862**	**1862**	3009	3009	2678	2678	3927	3927	2754	2754	3927	3927	3876	3876	3927	3927	3927	3927	2627	2627
F_{14}	3927	3927	3927	3927	2805	2805	3902	3902	2627	2627	3927	3927	2805	2805	3927	3927	2780	2780	3927	3927	3927	3927	2627	2627
F_{15}	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3405	3527
F_{16}	3927	3927	3927	3927	3927	3927	3927	3927	2627	2627	3927	3927	2831	2831	3927	3927	3800	3800	3927	3927	3927	3927	2754	2754
F_{17}	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	2856	3575
F_{18}	3927	3927	3927	3927	3927	3927	3927	3927	3647	3647	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927
F_{19}	3927	3927	3927	3927	3927	3927	3927	3927	3725	3752	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927	3927
F_{20}	3927	3927	3927	3927	3927	3927	3927	3927	2576	3392	3827	3927	3925	3927	3927	3927	3827	3927	3855	3927	3927	3927	3825	3927
w/t/l	12/7/1	12/6/2	19/1/0	19/1/0	13/5/2	13/6/1	16/4/0	16/4/0	8/10/2	10/8/2	18/2/0	18/2/0	7/9/4	8/9/3	15/4/1	14/3/3	13/7/0	13/7/0	18/2/0	18/2/0	12/6/2	12/6/2	4/12/4	7/10/3

TABLE SXXIII
THE CHANGE OF '*W/L/T*' OF LAMC-ACO (THE LEFT COLUMN) AND LAMS-ACO (THE RIGHT COLUMN) COMPARED WITH DIFFERENT ALGORITHMS WITH THE ACCURACY LEVEL INCREASING.

Accuracy Level / Algorithm / *w/t/l*	$\varepsilon = 1.0E-01$		$\varepsilon = 1.0E-02$		$\varepsilon = 1.0E-03$		$\varepsilon = 1.0E-04$		$\varepsilon = 1.0E-05$	
CDE	6/13/1	6/13/1	10/8/2	11/7/2	10/8/2	11/7/2	11/7/2	11/7/2	12/7/1	12/6/2
SDE	13/7/0	13/7/0	16/4/0	16/4/0	17/3/0	17/3/0	18/2/0	18/2/0	19/1/0	19/1/0
LIPS	12/8/0	12/8/0	13/5/2	13/6/1	13/5/2	13/6/1	13/5/2	13/6/1	13/5/2	13/6/1
R2PSO	10/10/0	10/10/0	14/6/0	15/5/0	15/5/0	15/5/0	15/5/0	16/4/0	16/4/0	16/4/0
NCDE	4/14/2	3/15/2	8/10/2	9/9/2	7/10/3	9/9/2	7/10/3	9/9/2	8/10/2	10/8/2
NSDE	7/12/1	7/12/1	15/5/0	15/5/0	18/2/0	18/2/0	18/2/0	18/2/0	18/2/0	18/2/0
Self_CCDE	3/15/2	3/15/2	6/10/4	7/10/3	7/9/4	8/9/3	7/9/4	8/9/3	7/9/4	8/9/3
Self_CSDE	10/10/0	10/10/0	13/7/0	14/6/0	14/5/1	15/5/0	14/5/1	13/7/0	15/4/1	14/3/3
LoICDE	3/15/2	3/15/2	8/10/2	8/10/2	9/9/2	10/8/2	11/9/0	11/8/1	13/7/0	13/7/0
LoISDE	8/12/0	8/12/0	16/4/0	16/4/0	18/2/0	18/2/0	18/2/0	18/2/0	18/2/0	18/2/0
PNPCDE	6/13/1	6/13/1	10/8/2	9/9/2	10/8/2	12/6/2	11/7/2	12/6/2	12/6/2	12/6/2
MOMMOP	3/14/3	2/15/3	5/9/6	5/10/5	5/10/5	7/10/3	5/10/5	7/10/3	4/12/4	7/10/3



(a) Function 1 (b) Function 2 (c) Function 3 (d) Function 4

(e) Function 5 (f) Function 6 (g) Function 7 (h) Function 8

(i) Function 9 (j) Function 10 (k) Function 11 (l) Function 12

(m) Function 13 (n) Function 14 (o) Function 15 (p) Function 16

(q) Function 17 (r) Function 18 (s) Function 19 (t) Function 20

Fig. S2. Comparison results with respect to the number of found global optima at the accuracy level $\varepsilon = 1.0E-04$ during the evolution process.

* In the following five tables (Tables SXXIV-SXXVIII), the comparison results with respect to PR and SR between LAMS-ACO and the winners of the CEC'2013 (NEA2) and the CEC'2015 (NMMSO) competitions on niching methods are presented with each table associated with one accuracy level. The best PR results are highlighted in bold in these tables and the last row (*b/e/w*) of these tables counts the number of functions on which LAMS-ACO is better than, equivalent to or worse than the compared winners. Note that whether LAMS-ACO is better than, equivalent to or worse than the compared winners is just determined by the values of PR without any statistical test validation, because we just cite the reported results of the two winners from the corresponding competitions (CEC'2013[2] and CEC'2015[3]) where the detailed results of these winners in each run are not available. Thus, to distinguish from the results obtained according to statistical tests, we utilize "*b/e/w*" in these tables, instead of "*w/t/l*" like in the above six tables.

TABLE SXXIV
COMPARISON RESULTS BETWEEN LAM-ACOS AND THE TWO WINNERS (NEA2 AND NMMSO) WITH RESPECT TO PR AND SR AT ACCURACY LEVEL ε=1.0E-01.

F	LAMS-ACO		NEA2		NMMSO	
	PR	SR	PR	SR	PR	SR
F_1	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000
F_2	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000
F_3	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000
F_4	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000
F_5	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000
F_6	0.992	0.863	0.963	0.480	**0.998**	0.960
F_7	**1.000**	1.000	0.946	0.160	**1.000**	1.000
F_8	0.803	0.000	0.241	0.000	**0.954**	0.060
F_9	0.350	0.000	0.622	0.000	**0.978**	0.120
F_{10}	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000
F_{11}	**1.000**	1.000	0.980	0.880	0.990	0.940
F_{12}	0.985	0.882	0.853	0.180	**0.995**	0.960
F_{13}	**0.993**	0.980	0.977	0.860	0.990	0.940
F_{14}	**1.000**	1.000	0.830	0.160	0.770	0.020
F_{15}	**0.995**	0.980	0.743	0.020	0.650	0.000
F_{16}	**1.000**	1.000	0.673	0.000	0.660	0.000
F_{17}	**0.988**	0.961	0.695	0.000	0.480	0.000
F_{18}	**1.000**	1.000	0.667	0.000	0.650	0.000
F_{19}	**0.897**	0.784	0.667	0.000	0.460	0.000
F_{20}	**0.632**	0.451	0.363	0.000	0.180	0.000
b/e/w	-		13/6/1		9/7/4	

[2] https://github.com/mikeagn/CEC2013/tree/master/NichingCompetition2013FinalData
[3] https://github.com/mikeagn/CEC2013/tree/master/NichingCompetition2015FinalData

TABLE SXXV

COMPARISON RESULTS BETWEEN LAM-ACOS AND THE TWO WINNERS (NEA2 AND NMMSO) WITH RESPECT TO PR AND SR AT ACCURACY LEVEL ε=1.0E-02.

F	LAMS-ACO		NEA2		NMMSO	
	PR	SR	PR	SR	PR	SR
F_1	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000
F_2	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000
F_3	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000
F_4	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000
F_5	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000
F_6	0.992	0.863	0.963	0.480	**0.994**	0.900
F_7	0.763	0.000	0.925	0.080	**1.000**	1.000
F_8	0.791	0.000	0.240	0.000	**0.939**	0.040
F_9	0.336	0.000	0.595	0.000	**0.978**	0.120
F_{10}	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000
F_{11}	0.984	0.902	0.967	0.800	**0.990**	0.940
F_{12}	0.983	0.863	0.850	0.180	**0.995**	0.960
F_{13}	0.693	0.000	0.970	0.820	**0.987**	0.920
F_{14}	0.667	0.000	**0.817**	0.100	0.740	0.020
F_{15}	**0.748**	0.000	0.723	0.000	0.647	0.000
F_{16}	0.667	0.000	**0.673**	0.000	0.660	0.000
F_{17}	**0.708**	0.000	0.695	0.000	0.477	0.000
F_{18}	**0.667**	0.000	**0.667**	0.000	0.650	0.000
F_{19}	0.502	0.000	**0.667**	0.000	0.460	0.000
F_{20}	0.348	0.000	**0.360**	0.000	0.175	0.000
b/e/w	-		6/7/7		6/6/8	

TABLE SXXVI

COMPARISON RESULTS BETWEEN LAM-ACOS AND THE TWO WINNERS (NEA2 AND NMMSO) WITH RESPECT TO PR AND SR AT ACCURACY LEVEL ε=1.0E-03.

F	LAMS-ACO		NEA2		NMMSO	
	PR	SR	PR	SR	PR	SR
F_1	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000
F_2	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000
F_3	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000
F_4	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000
F_5	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000
F_6	0.990	0.824	0.958	0.440	**0.992**	0.880
F_7	0.716	0.000	0.918	0.060	**1.000**	1.000
F_8	0.782	0.000	0.240	0.000	**0.922**	0.020
F_9	0.295	0.000	0.584	0.000	**0.978**	0.120
F_{10}	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000
F_{11}	0.974	0.843	0.967	0.800	**0.990**	0.940
F_{12}	0.983	0.863	0.843	0.180	**0.995**	0.960
F_{13}	0.676	0.000	0.960	0.760	**0.983**	0.900
F_{14}	0.667	0.000	**0.810**	0.080	0.723	0.020
F_{15}	**0.748**	0.000	0.720	0.000	0.642	0.000
F_{16}	0.667	0.000	**0.673**	0.000	0.660	0.000
F_{17}	**0.708**	0.000	0.695	0.000	0.470	0.000
F_{18}	**0.667**	0.000	**0.667**	0.000	0.650	0.000
F_{19}	0.502	0.000	**0.667**	0.000	0.457	0.000
F_{20}	0.348	0.000	**0.360**	0.000	0.172	0.000
b/e/w	-		6/7/7		6/6/8	

TABLE SXXVII

COMPARISON RESULTS BETWEEN LAM-ACOS AND THE TWO WINNERS (NEA2 AND NMMSO) WITH RESPECT TO PR AND SR AT ACCURACY LEVEL ε=1.0E-04.

F	LAMS-ACO		NEA2		NMMSO	
	PR	SR	PR	SR	PR	SR
F_1	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000
F_2	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000
F_3	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000
F_4	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000
F_5	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000
F_6	0.990	0.824	0.950	0.380	**0.992**	0.880
F_7	0.683	0.000	0.914	0.040	**1.000**	1.000
F_8	0.765	0.000	0.240	0.000	**0.899**	0.020
F_9	0.254	0.000	0.581	0.000	**0.978**	0.120
F_{10}	**1.000**	1.000	0.988	0.860	**1.000**	1.000
F_{11}	0.961	0.765	0.960	0.760	**0.990**	0.940
F_{12}	0.983	0.863	0.840	0.160	**0.993**	0.940
F_{13}	0.670	0.000	0.957	0.740	**0.983**	0.900
F_{14}	0.667	0.000	**0.807**	0.060	0.720	0.000
F_{15}	**0.748**	0.000	0.718	0.000	0.632	0.000
F_{16}	0.667	0.000	**0.673**	0.000	0.660	0.000
F_{17}	**0.708**	0.000	0.695	0.000	0.468	0.000
F_{18}	**0.667**	0.000	**0.667**	0.000	0.650	0.000
F_{19}	0.502	0.000	**0.667**	0.000	0.450	0.000
F_{20}	0.346	0.000	**0.360**	0.000	0.172	0.000
b/e/w	-		7/6/7		6/6/8	

TABLE SXXVIII

COMPARISON RESULTS BETWEEN LAM-ACOS AND THE TWO WINNERS (NEA2 AND NMMSO) WITH RESPECT TO PR AND SR AT ACCURACY LEVEL ε=1.0E-05.

F	LAMS-ACO		NEA2		NMMSO	
	PR	SR	PR	SR	PR	SR
F_1	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000
F_2	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000
F_3	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000
F_4	**1.000**	1.000	0.990	0.960	**1.000**	1.000
F_5	**1.000**	1.000	**1.000**	1.000	**1.000**	1.000
F_6	**0.990**	0.824	0.000	0.000	0.000	0.000
F_7	0.660	0.000	0.911	0.040	**1.000**	1.000
F_8	0.647	0.000	0.239	0.000	**0.870**	0.000
F_9	0.235	0.000	0.579	0.000	**0.978**	0.120
F_{10}	**1.000**	1.000	0.980	0.760	**1.000**	1.000
F_{11}	0.944	0.667	0.960	0.760	**0.990**	0.940
F_{12}	0.980	0.843	0.833	0.140	**0.990**	0.920
F_{13}	0.667	0.000	0.947	0.700	**0.983**	0.900
F_{14}	0.667	0.000	**0.800**	0.060	0.720	0.000
F_{15}	**0.748**	0.000	0.713	0.000	0.632	0.000
F_{16}	0.667	0.000	**0.673**	0.000	0.660	0.000
F_{17}	0.625	0.000	**0.695**	0.000	0.460	0.000
F_{18}	**0.667**	0.000	0.663	0.000	0.650	0.000
F_{19}	0.502	0.000	**0.667**	0.000	0.437	0.000
F_{20}	0.333	0.000	**0.350**	0.000	0.172	0.000
b/e/w	-		7/4/9		7/6/7	

IV. APPENDIX

In this section, we present how to obtain the critical value with respect to the rank sum for Wilcoxon Rank Sum test, when the sizes of samples are larger than 10.

Assume that there are two samples A and B whose sizes are n_A and n_B respectively, and w_A denotes the sum of the ranks for observations from A. Then, according to [S1][4], we can treat the distribution of w_A as if it were normal distribution in the form of $N(\mu_A, \sigma_A)$, when both sample sizes are 10 or larger, where

$$\mu_A = \frac{n_A(n_A + n_B + 1)}{2}$$
$$\sigma_A = \sqrt{\frac{n_A n_B (n_A + n_B + 1)}{12}} \quad \text{(S.1)}$$

More precisely,

$$pr(W_A \geq w_A) \approx pr(Z \geq z) = 1 - pr(Z < z)$$
$$z = \frac{w_A - \mu_A}{\sigma_A} \quad \text{(S.2)}$$

At the significance level of α=0.05, we have

$$pr(Z \geq z) \leq 0.05 \quad \text{(S.3)}$$

According to Eq. (S.2), we have

$$pr(Z < z) \geq 0.95 \quad \text{(S.4)}$$

Then, referring to the table values of the standard normal distribution shown in Table SXXIX, we have

$$\frac{w_A - \mu_A}{\sigma_A} \geq 1.65 \quad \text{(S.5)}$$

In our case, both of the two sample sizes are 51, namely n_A=n_B=51. Thus, we can obtain

$$\mu_A = \frac{n_A(n_A + n_B + 1)}{2} = \frac{51 \times (51 + 51 + 1)}{2} = 2626.5$$
$$\sigma_A = \sqrt{\frac{n_A n_B (n_A + n_B + 1)}{12}} = \sqrt{\frac{51 \times 51 \times (51 + 51 + 1)}{12}} = 149.42 \quad \text{(S.6)}$$

Based on Eq. (S.5), we can get

$$w_A \geq 1.65 \times \sigma_A + \mu_A = 1.65 \times 149.42 + 2626.5 \approx 2873 \quad \text{(S.7)}$$

Thus, the critical value of the Wilcoxon Rank Sum Test for 51 samples is 2873.

Reference

[S1] C. J. Wild, *Chance encounters: A first course in data analysis and inference*: Wiley, 2000.

[4] Specifically, please refer to https://www.stat.auckland.ac.nz/~wild/ChanceEnc/Ch10.wilcoxon.pdf.

TABLE SXXIX
TABLE VALUES FOR THE STANDARD NORMAL DISTRIBUTION

Z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	.50000	.50399	.50798	.51197	.51595	.51994	.52392	.52790	.53188	.53586
0.1	.53983	.54380	.54776	.55172	.55567	.55962	.56356	.56749	.57142	.57535
0.2	.57926	.58317	.58706	.59095	.59483	.59871	.60257	.60642	.61026	.61409
0.3	.61791	.62172	.62552	.62930	.63307	.63683	.64058	.64431	.64803	.65173
0.4	.65542	.65910	.66276	.66640	.67003	.67364	.67724	.68082	.68439	.68793
0.5	.69146	.69497	.69847	.70194	.70540	.70884	.71226	.71566	.71904	.72240
0.6	.72575	.72907	.73237	.73565	.73891	.74215	.74537	.74857	.75175	.75490
0.7	.75804	.76115	.76424	.76730	.77035	.77337	.77637	.77935	.78230	.78524
0.8	.78814	.79103	.79389	.79673	.79955	.80234	.80511	.80785	.81057	.81327
0.9	.81594	.81859	.82121	.82381	.82639	.82894	.83147	.83398	.83646	.83891
1.0	.84134	.84375	.84614	.84849	.85083	.85314	.85543	.85769	.85993	.86214
1.1	.86433	.86650	.86864	.87076	.87286	.87493	.87698	.87900	.88100	.88298
1.2	.88493	.88686	.88877	.89065	.89251	.89435	.89617	.89796	.89973	.90147
1.3	.90320	.90490	.90658	.90824	.90988	.91149	.91309	.91466	.91621	.91774
1.4	.91924	.92073	.92220	.92364	.92507	.92647	.92785	.92922	.93056	.93189
1.5	.93319	.93448	.93574	.93699	.93822	.93943	.94062	.94179	.94295	.94408
1.6	.94520	.94630	.94738	.94845	.94950	.95053	.95154	.95254	.95352	.95449
1.7	.95543	.95637	.95728	.95818	.95907	.95994	.96080	.96164	.96246	.96327
1.8	.96407	.96485	.96562	.96638	.96712	.96784	.96856	.96926	.96995	.97062
1.9	.97128	.97193	.97257	.97320	.97381	.97441	.97500	.97558	.97615	.97670
2.0	.97725	.97778	.97831	.97882	.97932	.97982	.98030	.98077	.98124	.98169
2.1	.98214	.98257	.98300	.98341	.98382	.98422	.98461	.98500	.98537	.98574
2.2	.98610	.98645	.98679	.98713	.98745	.98778	.98809	.98840	.98870	.98899
2.3	.98928	.98956	.98983	.99010	.99036	.99061	.99086	.99111	.99134	.99158
2.4	.99180	.99202	.99224	.99245	.99266	.99286	.99305	.99324	.99343	.99361
2.5	.99379	.99396	.99413	.99430	.99446	.99461	.99477	.99492	.99506	.99520
2.6	.99534	.99547	.99560	.99573	.99585	.99598	.99609	.99621	.99632	.99643
2.7	.99653	.99664	.99674	.99683	.99693	.99702	.99711	.99720	.99728	.99736
2.8	.99744	.99752	.99760	.99767	.99774	.99781	.99788	.99795	.99801	.99807
2.9	.99813	.99819	.99825	.99831	.99836	.99841	.99846	.99851	.99856	.99861
3.0	.99865	.99869	.99874	.99878	.99882	.99886	.99889	.99893	.99896	.99900
3.1	.99903	.99906	.99910	.99913	.99916	.99918	.99921	.99924	.99926	.99929
3.2	.99931	.99934	.99936	.99938	.99940	.99942	.99944	.99946	.99948	.99950
3.3	.99952	.99953	.99955	.99957	.99958	.99960	.99961	.99962	.99964	.99965
3.4	.99966	.99968	.99969	.99970	.99971	.99972	.99973	.99974	.99975	.99976
3.5	.99977	.99978	.99978	.99979	.99980	.99981	.99981	.99982	.99983	.99983
3.6	.99984	.99985	.99985	.99986	.99986	.99987	.99987	.99988	.99988	.99989
3.7	.99989	.99990	.99990	.99990	.99991	.99991	.99992	.99992	.99992	.99992
3.8	.99993	.99993	.99993	.99994	.99994	.99994	.99994	.99995	.99995	.99995
3.9	.99995	.99995	.99996	.99996	.99996	.99996	.99996	.99996	.99997	.99997