Empirical Evaluation of weighted Heuristic Search with advanced Mini-Bucket Heuristics for Graphical Models

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Abstract

Weighted search (best-first or depth-first) refers to search with a heuristic function multiplied by a constant w [5]. The current work extends the previous investigation of weighted search algorithms with the mini-bucket heuristic [3]. We perform empirical analysis of various such algorithms with more advanced heuristics such as Join-Graph Linear Programming [4] and Mini-Bucket Elimination with Moment Matching [2].

1 Introduction

The algorithms wAOBF (weighted AND/OR Best First), wR-AOBF (weighted Repairing-AOBF) and wAOBB (weighted AND/OR Branch and Bound) were studied with JGLP (Join Graph Linear Programming) and MBE-MM (Mini-Bucket Elimination with Moment Matching) heuristics.

Strength of the above heuristics is controlled by the *i-bound* parameter. Higher i-bounds typically yield more accurate heuristics but take more time and space, which is exponential in the i-bound. i-bounds ranging from 2 to 18 were used for the experiments.

The empirical results presented here were produced by running the algorithms implemented in C++, with a memory limit of 4 GB and a time limit of 6 hours on 2.67GHz Intel Xeon X5650 machines.

The algorithms were tested on a variety of benchmarks obtained from previous UAI [1] inference competitions. The following labels (refering to the benchmark) will be found interspersed in the results:

Benchmark	Instance
Pedigrees	pedigree31 pedigree33 pedigree37
WCSPs	505.wcsp 404.wcsp driverlog02ac.wcsp
Type 4	type4b_100_16 type4b_100_19 type4b_120_17
Grids	75-18-5 75-19-5 75-20-5
Proteins	pdb1aly pdb2eif pdb1iqz
Image Alignment	fileforGal_150markers fileforGal_200markers fileforGal_250markers
Object Detection	giraffe_rescaled_3016.K10.F100.model giraffe_rescaled_3016.K15.F100.model deer_rescaled_3020.K20.F100.model
Segmentation	12_4_s.21 14_26_s.21 15_3_s.21

2 Results

2.1 log(cost) as a funtion of time

2.1.1 Comparison of algorithms with MBE-MM heuristic

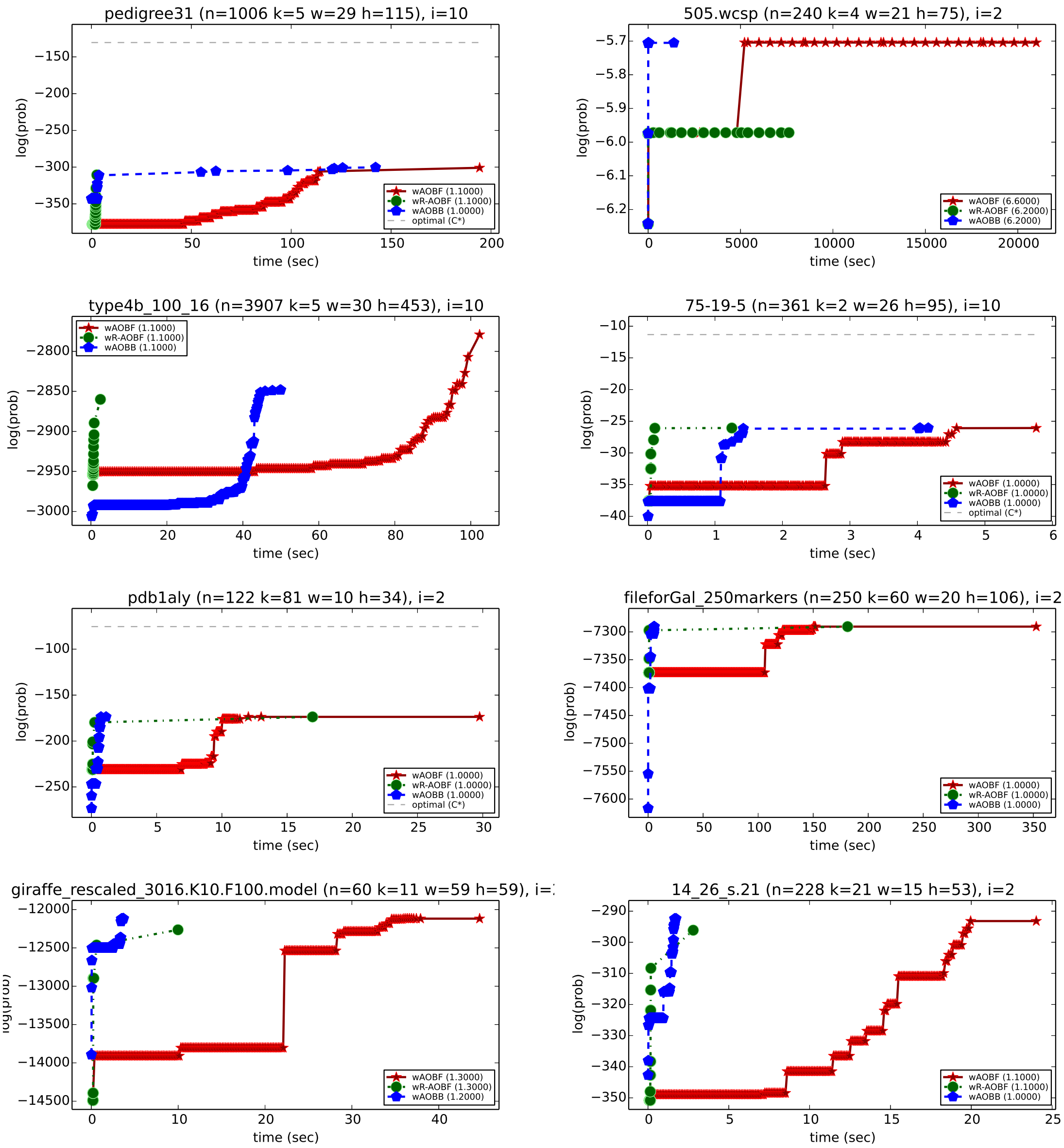


Figure 1: Solution log-cost vs time (sec) for algorithms wAOBF, wR-AOBF and wAOBB. Starting weight = 64. Instance parameters are in format (n, k, w^*, h_T), where n - number of variables, k - max. domain size, w^* - induced width, h_T - pseudo-tree height.

2.1.2 Comparison of algorithms with JGLP heuristic

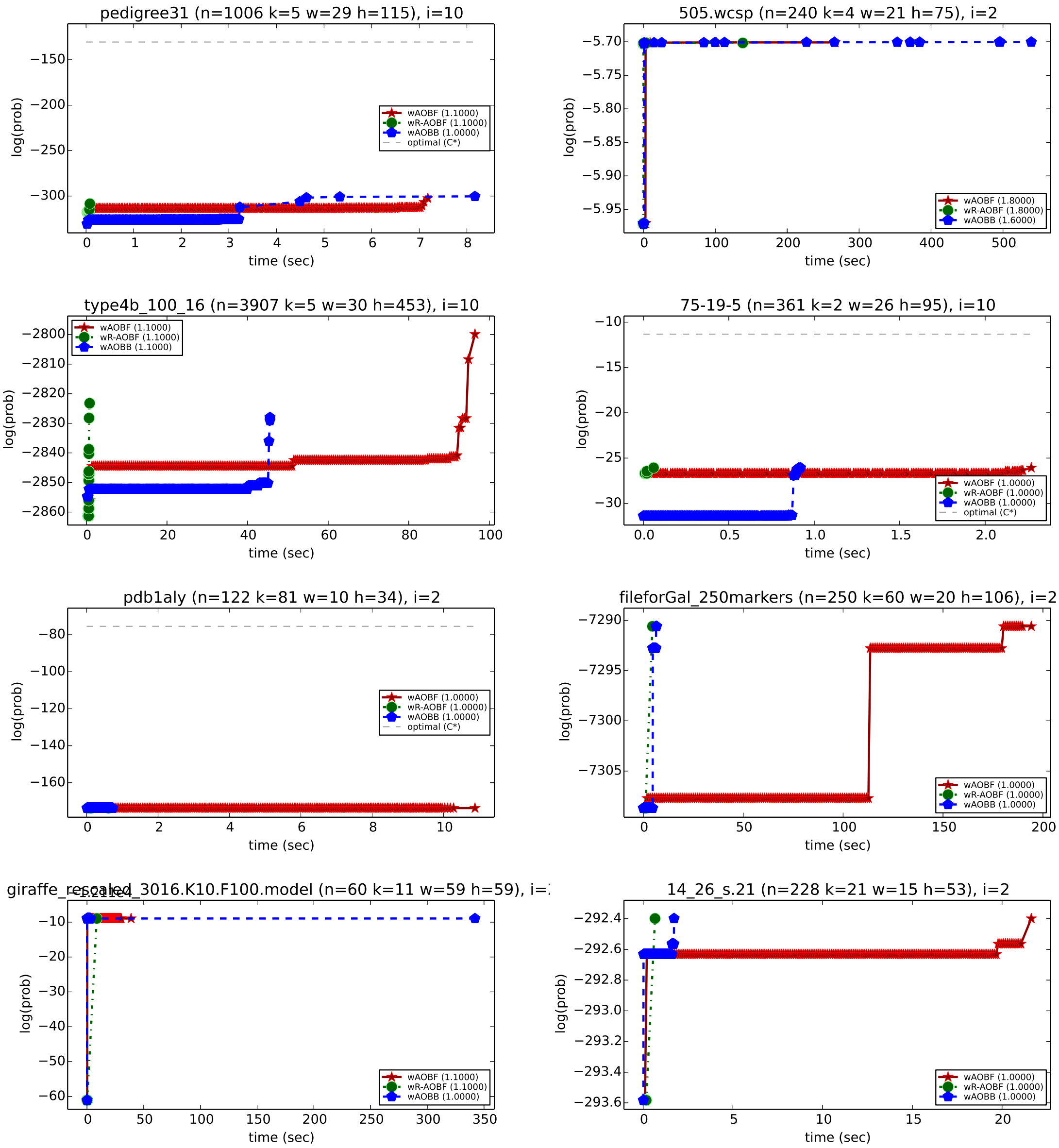


Figure 2: Solution log-cost vs time (sec) for algorithms wAOBF, wR-AOBF and wAOBB. Starting weight = 64. Instance parameters are in format (n, k, w^*, h_T), where n - number of variables, k - max. domain size, w^* - induced width, h_T - pseudo-tree height.

2.1.3 Comparison of different heuristics with wAOBF algorithm

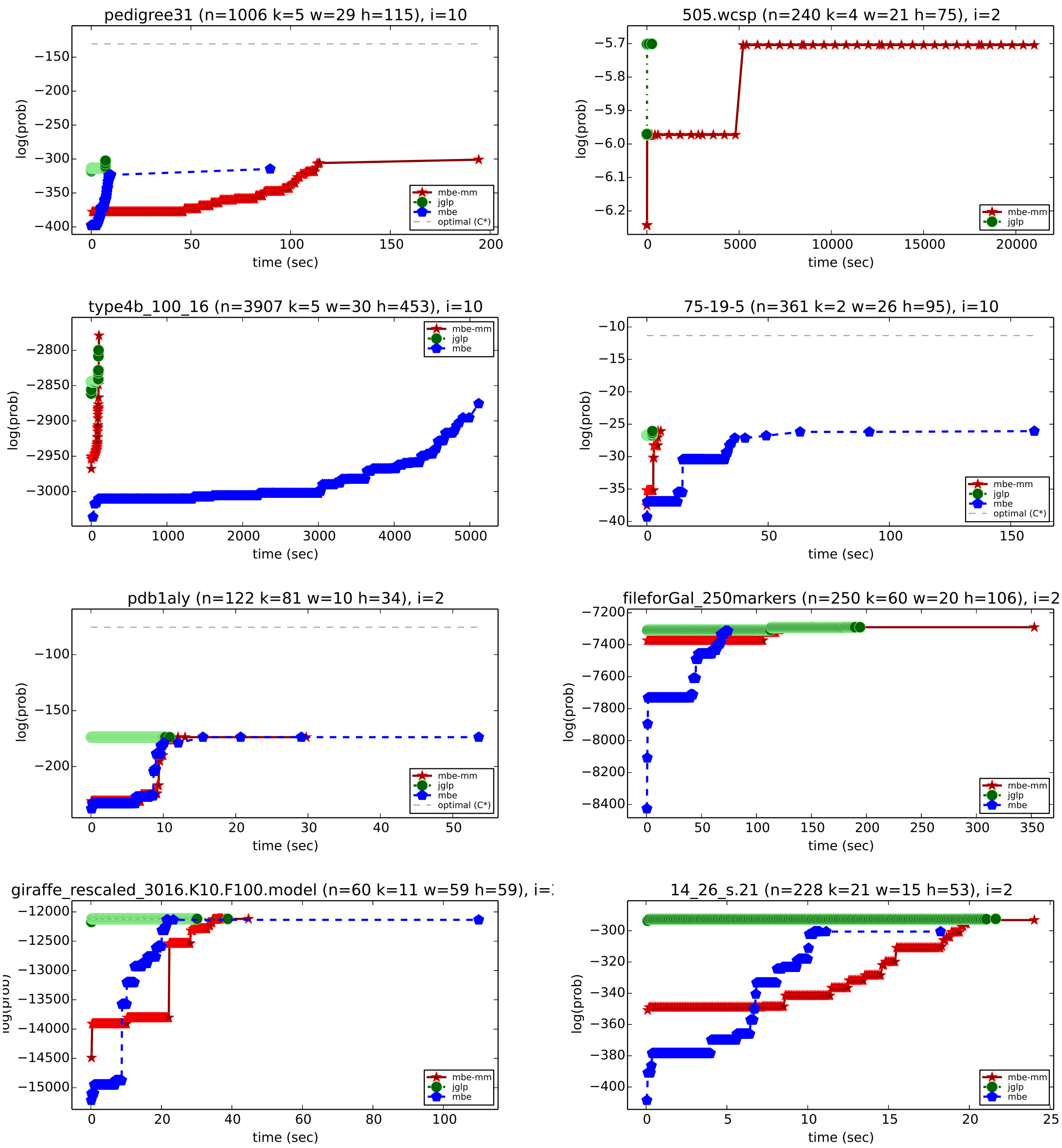


Figure 3: Solution log-cost vs time (sec) for heuristics MBE-MM, JGLP and MBE. Starting weight = 64. Instance parameters are in format (n, k, w^*, h_T), where n - number of variables, k - max. domain size, w^* - induced width, h_T - pseudo-tree height.

2.1.4 Comparison of different heuristics with wR-AOBF algorithm

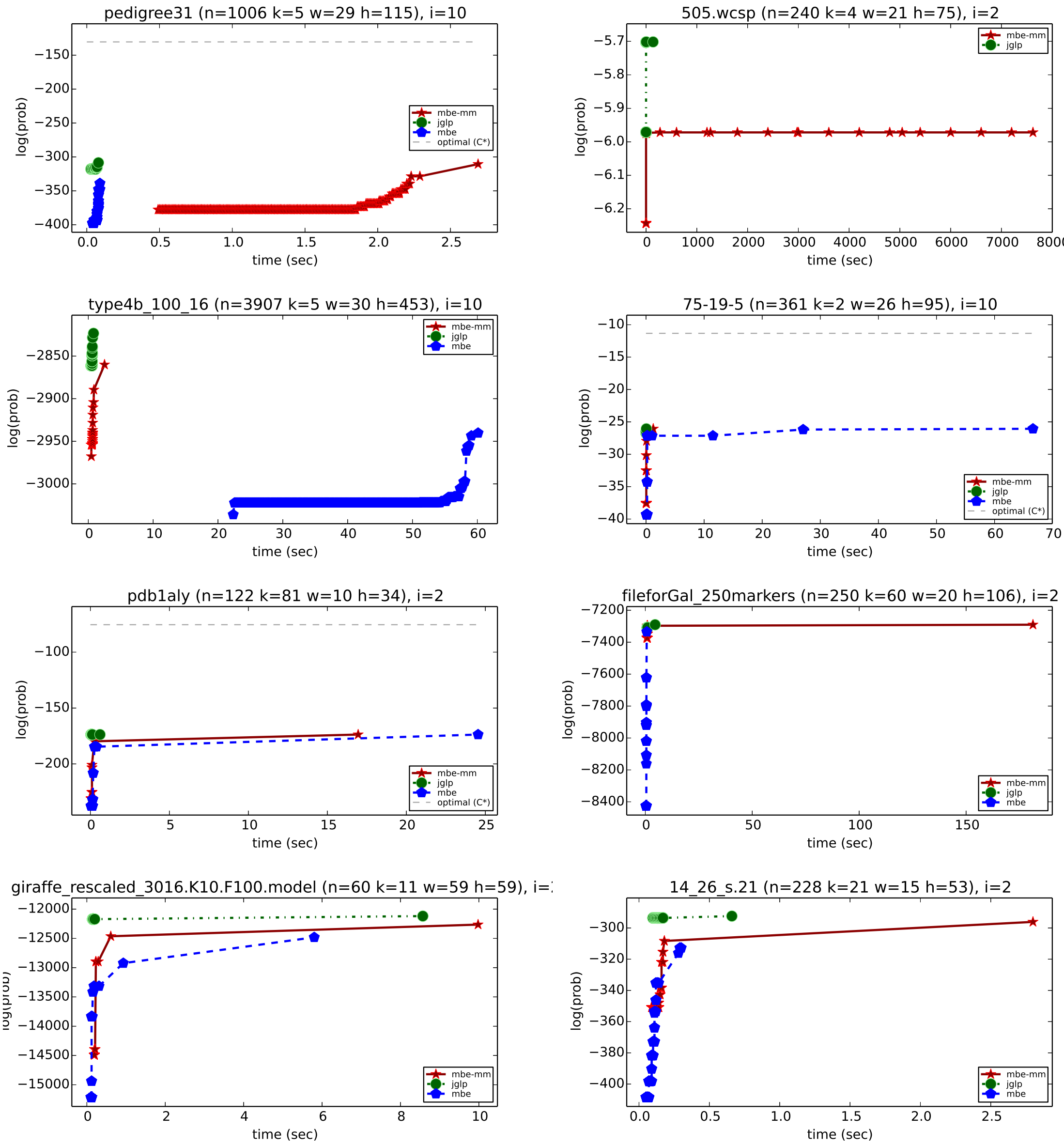


Figure 4: Solution log-cost vs time (sec) for heuristics MBE-MM, JGLP and MBE. Starting weight = 64. Instance parameters are in format (n, k, w^*, h_T), where n - number of variables, k - max. domain size, w^* - induced width, h_T - pseudo-tree height.

2.1.5 Comparison of different heuristics with wAOBB algorithm

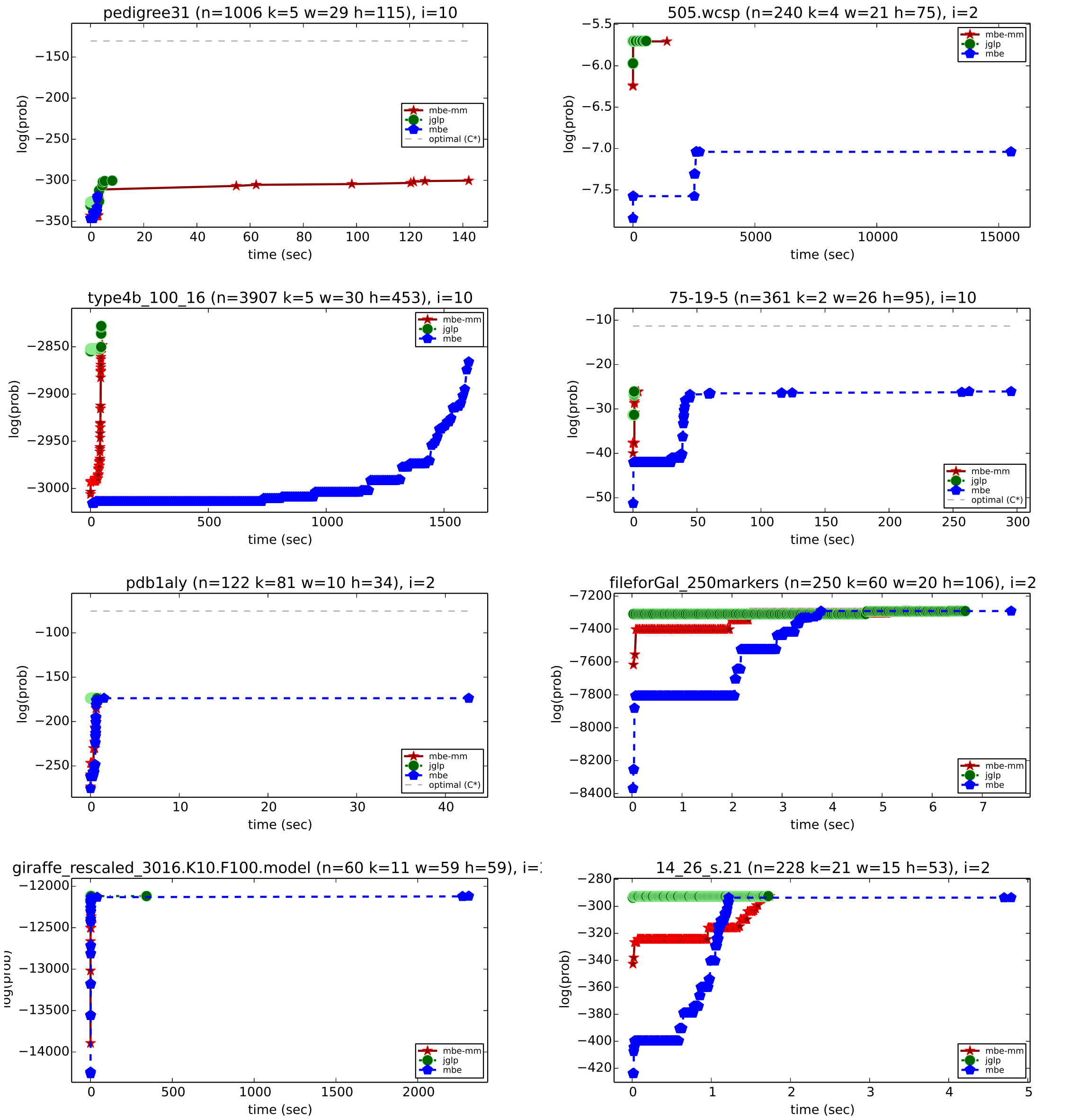
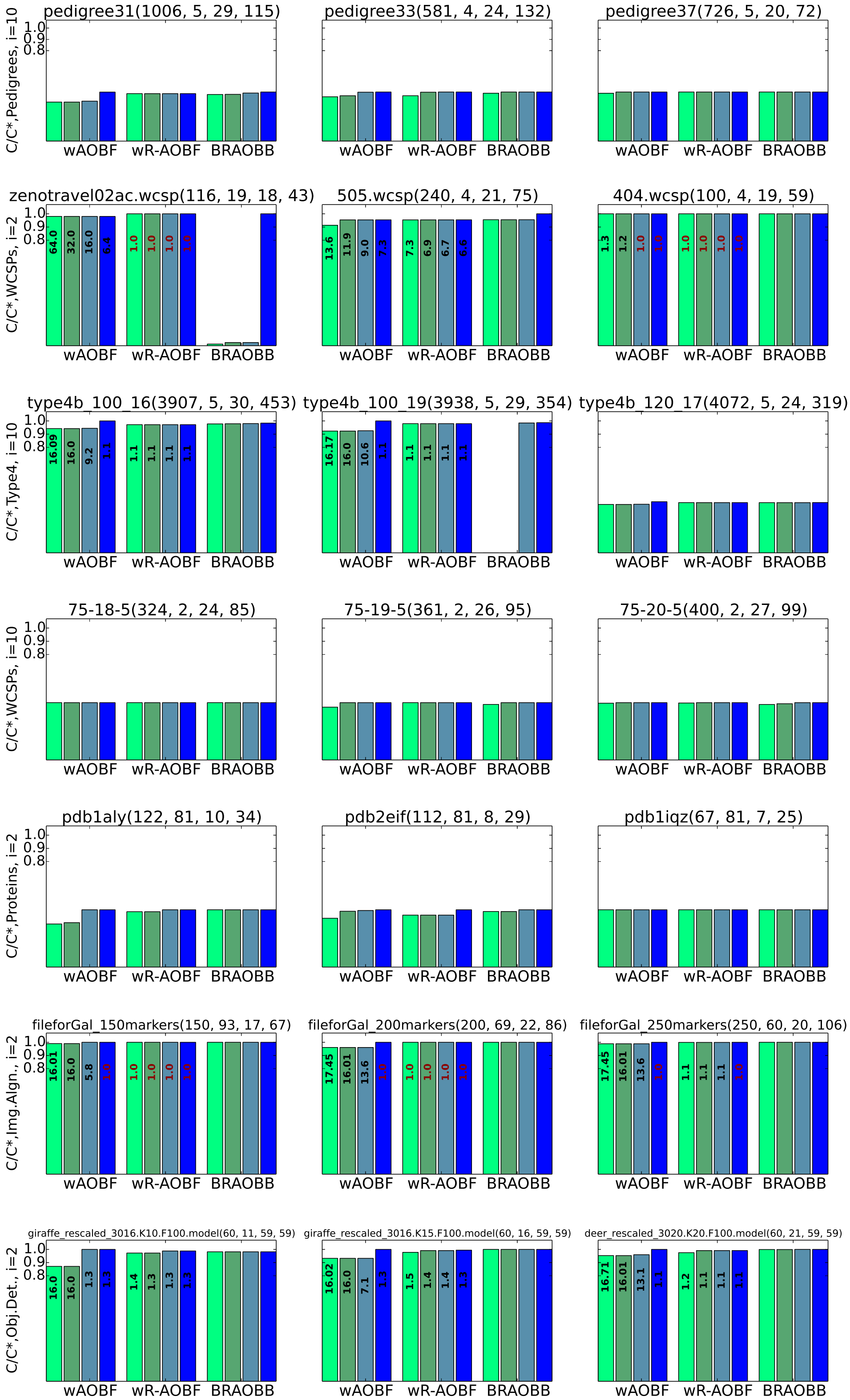


Figure 5: Solution log-cost vs time (sec) for heuristics MBE-MM, JGLP and MBE. Starting weight = 64. Instance parameters are in format (n, k, w^*, h_T), where n - number of variables, k - max. domain size, w^* - induced width, h_T - pseudo-tree height.

2.2 C/C* for various time bounds in different algorithms

2.2.1 Comparison of different algorithms with MBE-MM heuristic



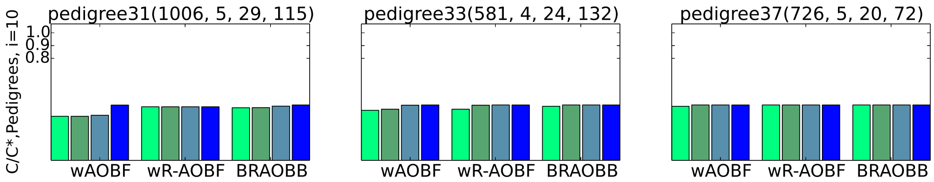
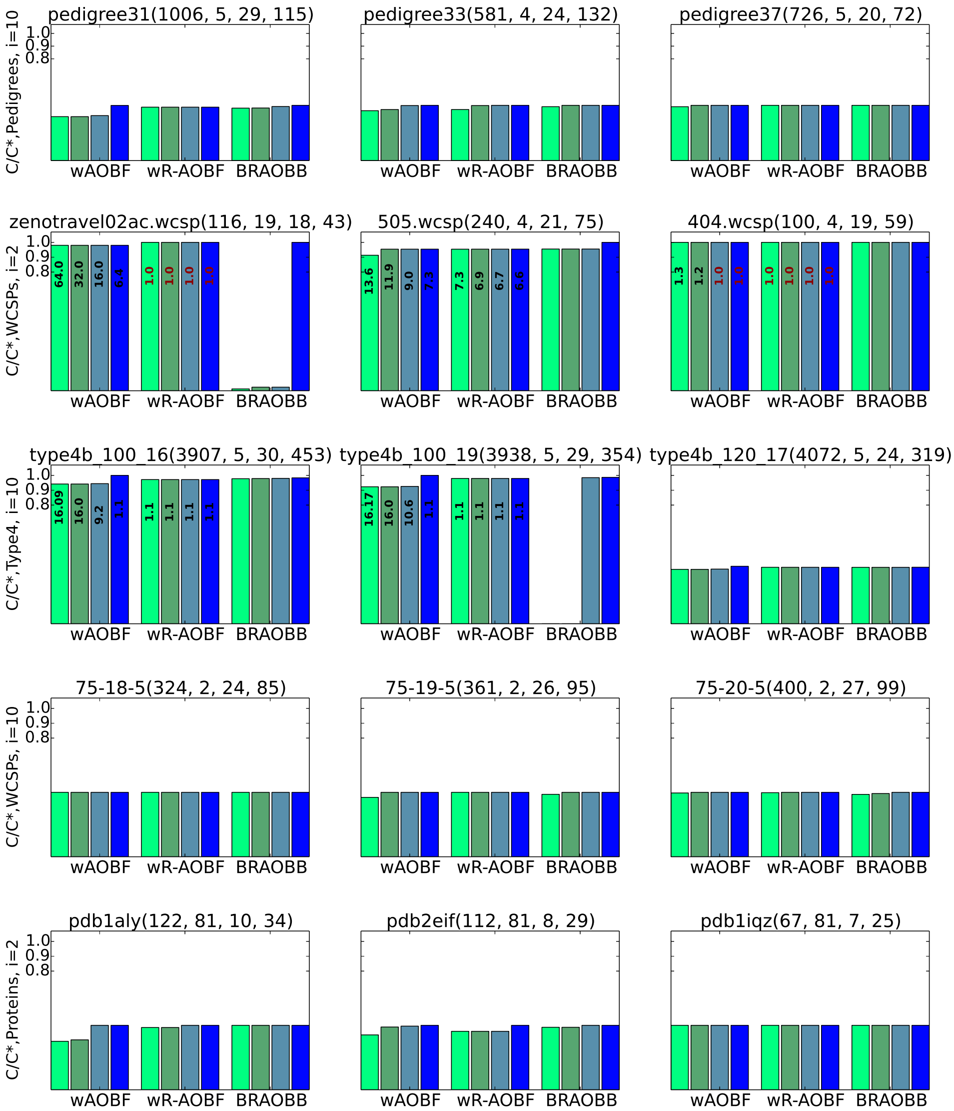


Figure 6: Ratio of the cost obtained by some point (10, 60, 600 and 1800 sec) and max cost. Max. cost = optimal, if known, otherwise = best cost found for the problem. Corresponding weight - above the bars. Instance parameters are in format (n, k, w^*, h_T), where n - number of variables, k - max. domain size, w^* - induced width, h_T - pseudo-tree height.

2.2.2 Comparison of different algorithms with JGLP heuristic



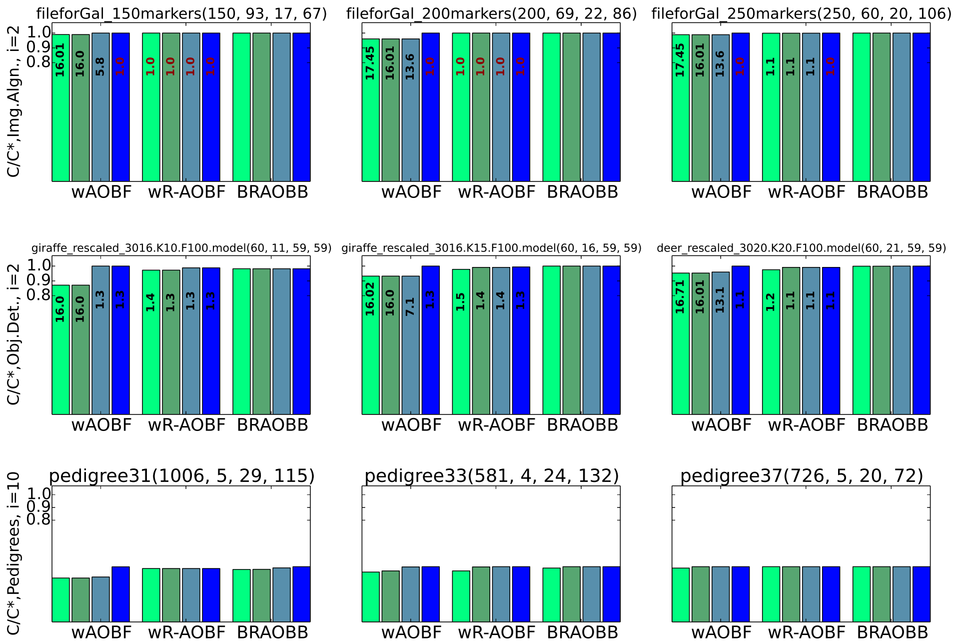
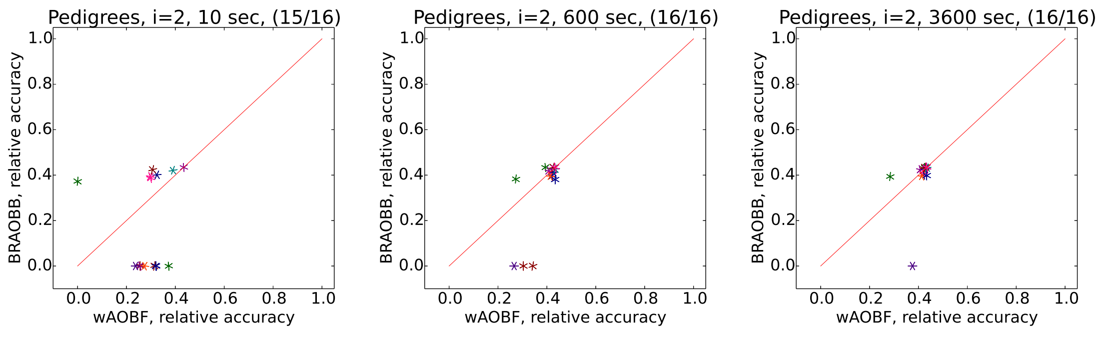


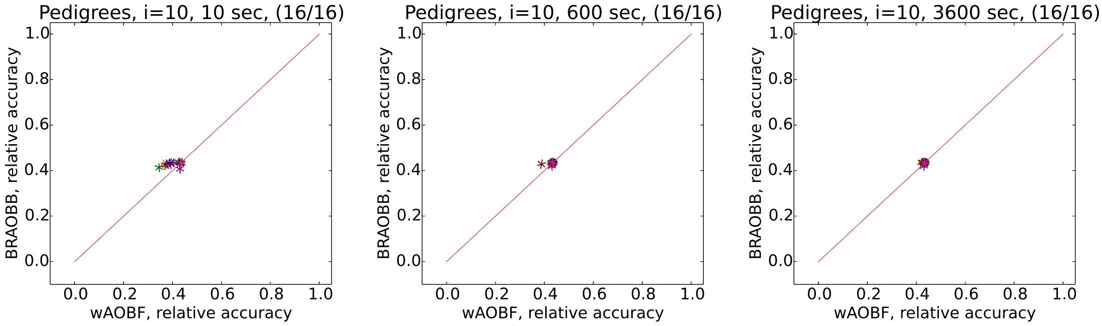
Figure 7: Ratio of the cost obtained by some point (10, 60, 600 and 1800 sec) and max cost. Max. cost = optimal, if known, otherwise = best cost found for the problem. Corresponding weight - above the bars. Instance parameters are in format (n, k, w^*, h_T), where n - number of variables, k - max. domain size, w^* - induced width, h_T - pseudo-tree height.

2.3 Comparison of relative accuracies of algorithms for a given time bound

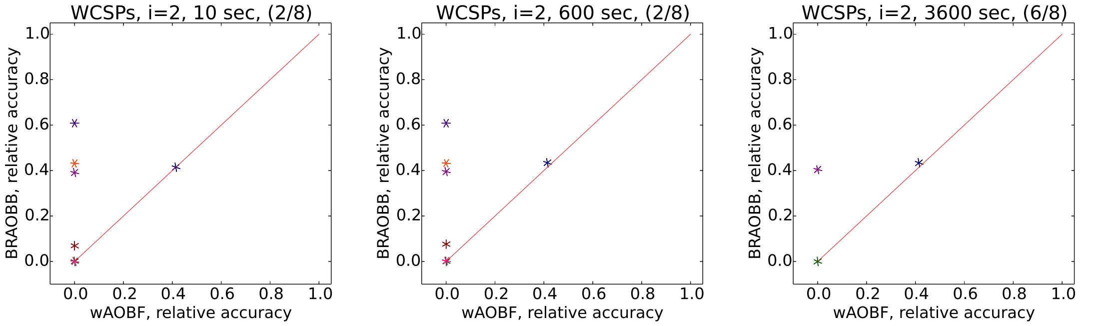
2.3.1 wAOBF vs BRAOBB with MBE-MM heuristic



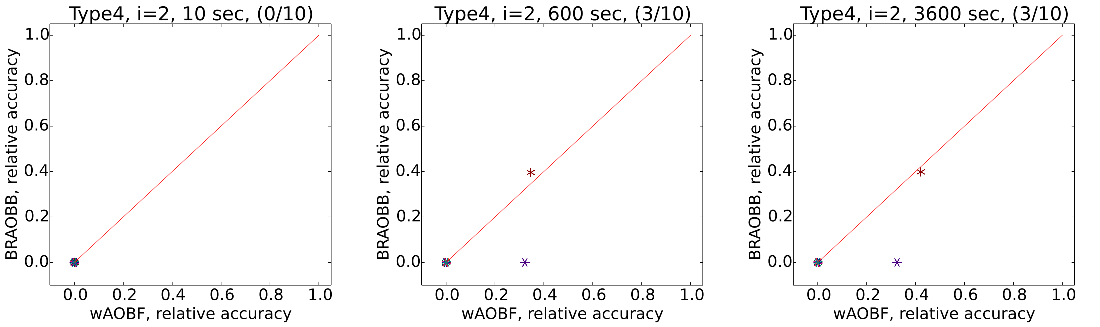
(a) Pedigrees, i=2



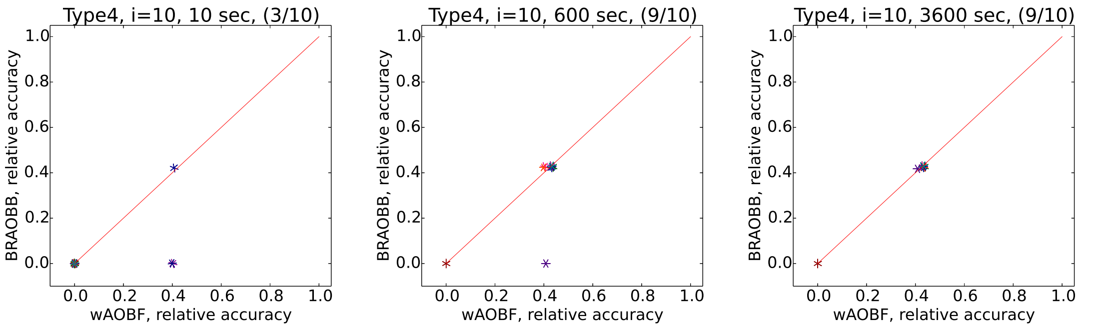
(b) Pedigrees, i=10



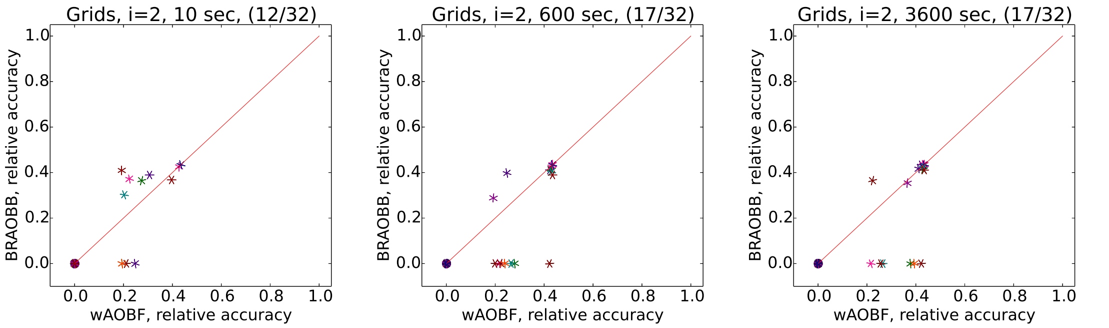
(c) WCSPs, i=2



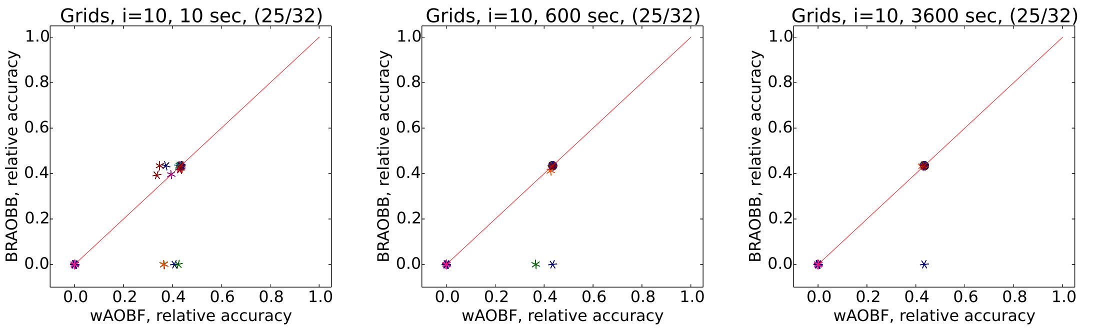
(d) Type4, i=2



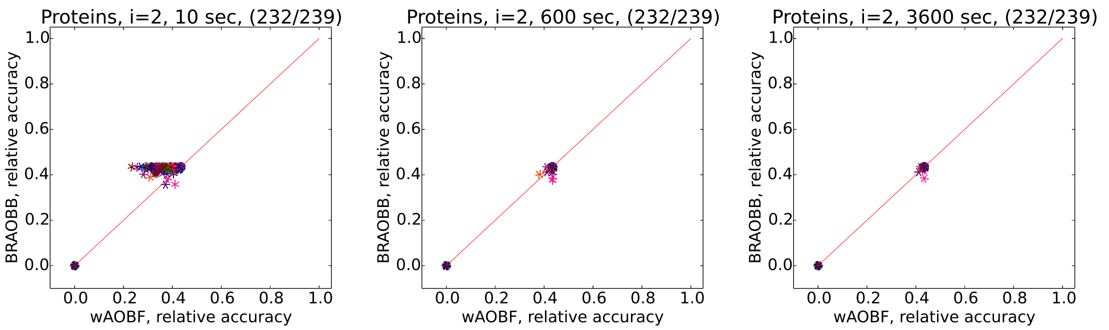
(e) Type4, i=10



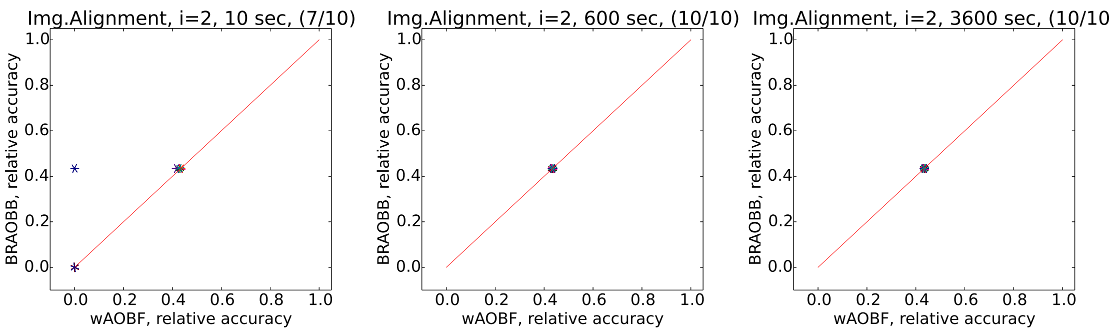
(f) Grids, i=2



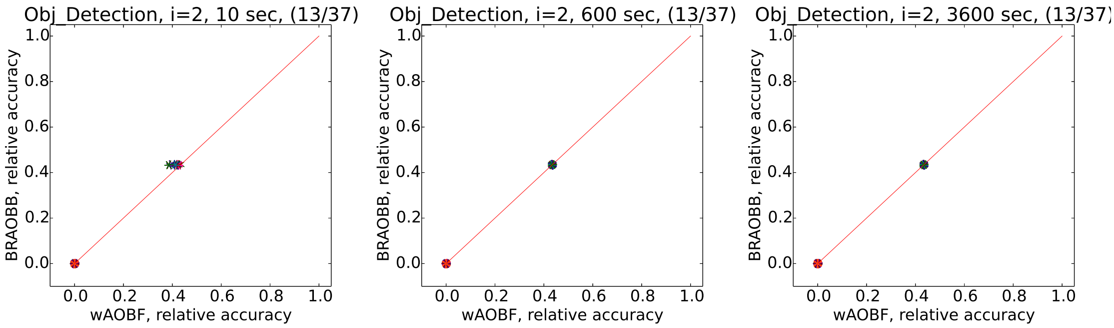
(g) Grids, i=10



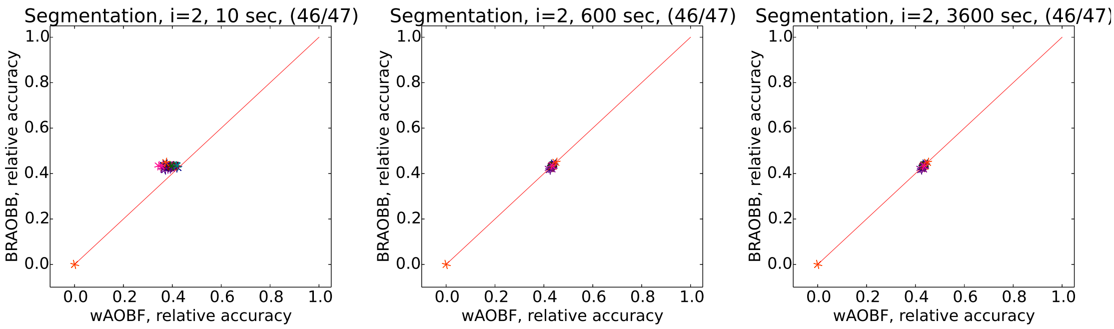
(h) Proteins, i=2



(i) Image Alignment, i=2



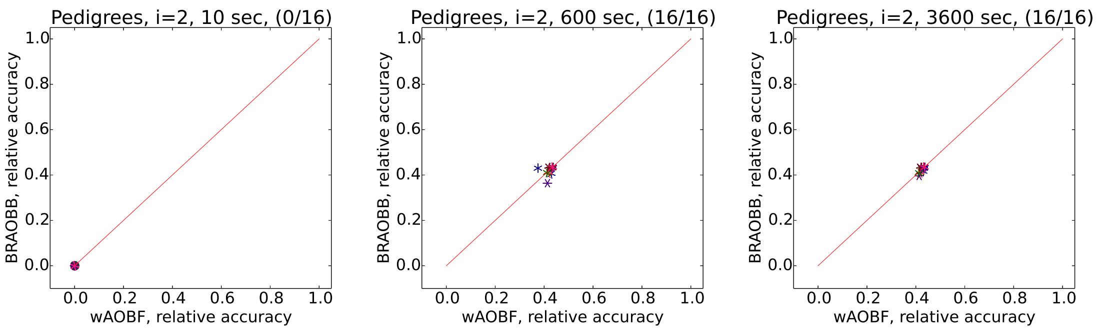
(j) Object Detection, i=2



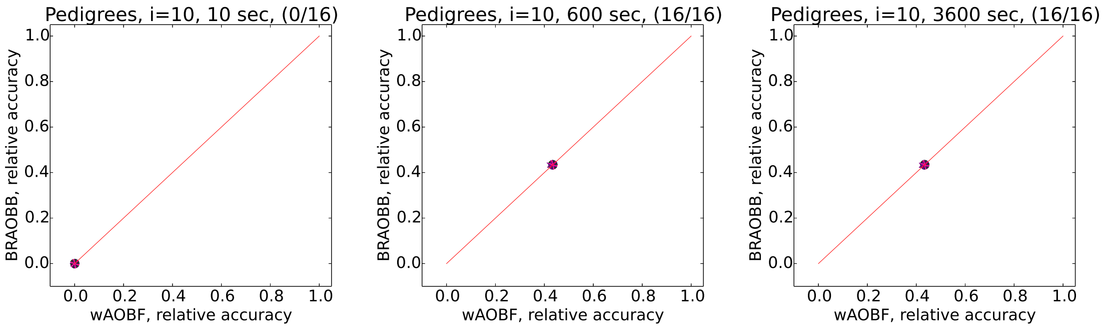
(k) Segmentation, i=2

Figure 8: wAOBF vs BRAOBB with MBE-MM heuristic on all benchmarks. Comparison of relative accuracy at times 10, 600 and 3600 sec. Each row - a single time bound. Each marker represents a single instance. In parenthesis (X/Y): X - # instances, for which at least one algorithm found a solution, Y - total # instances. Only i=2 case is reported for benchmarks where heuristic computation with higher i-bound was infeasible.

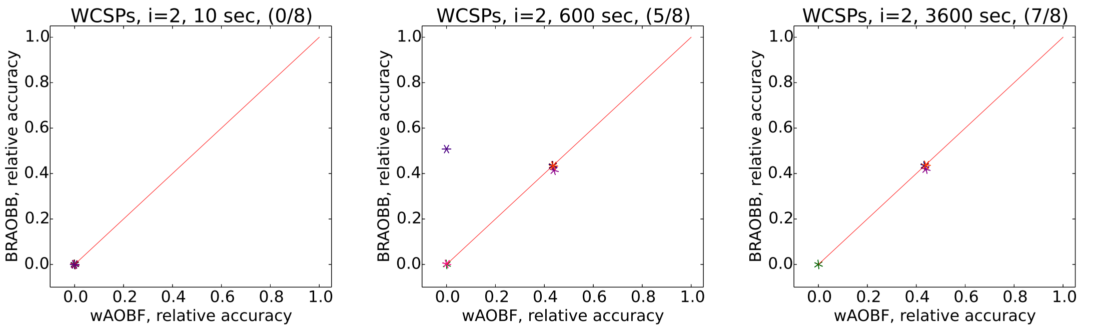
2.3.2 wAOBF vs BRAOBB with JGLP heuristic



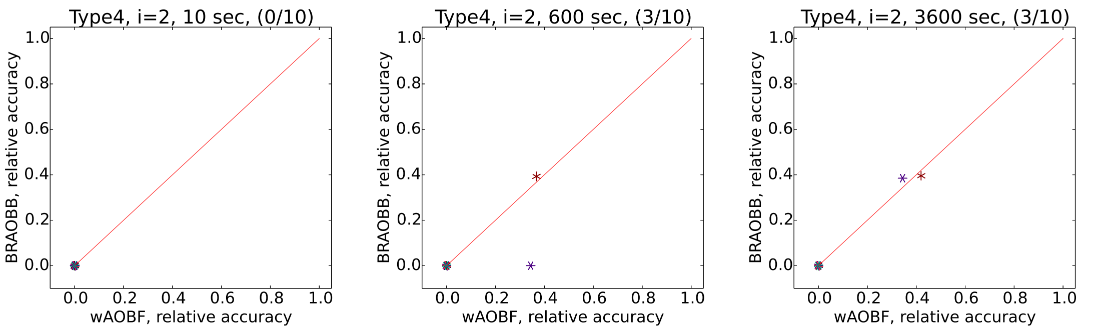
(a) Pedigrees, i=2



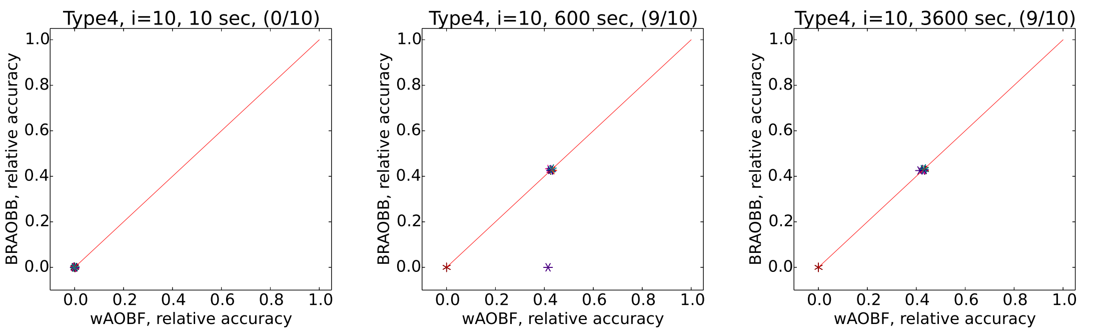
(b) Pedigrees, i=10



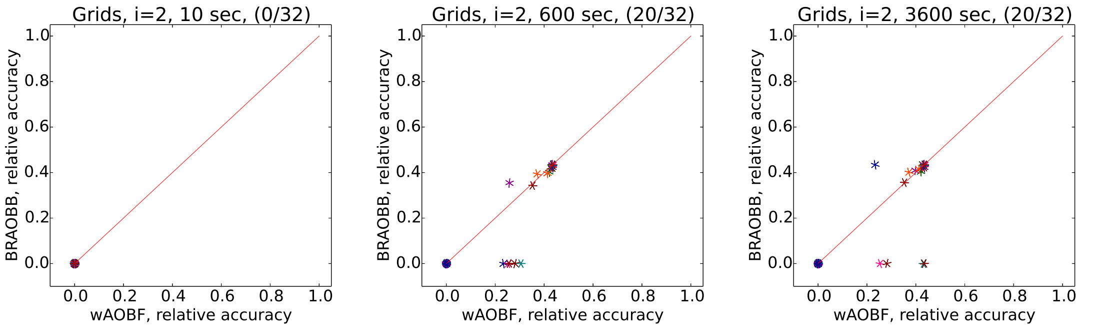
(c) WCSPs, i=2



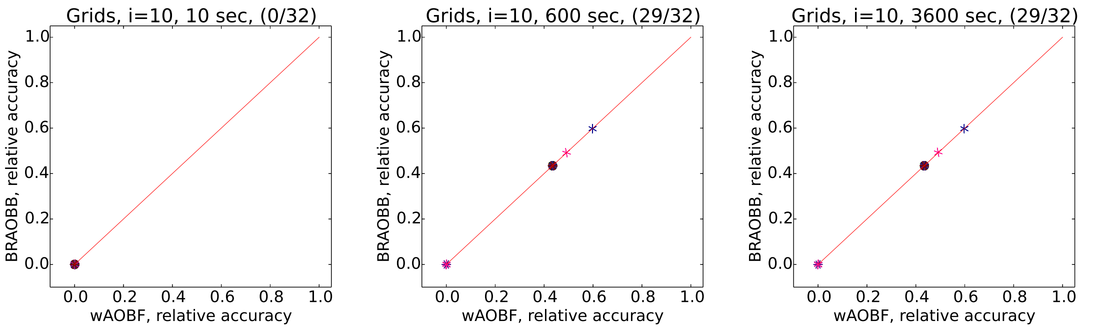
(d) Type4, i=2



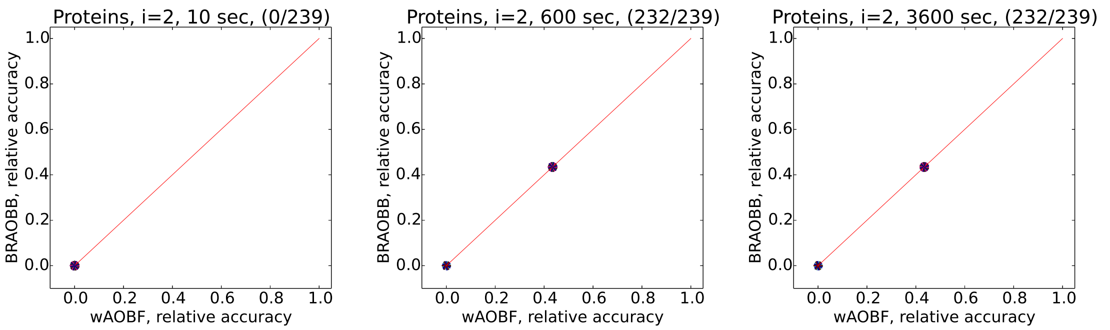
(e) Type4, i=10



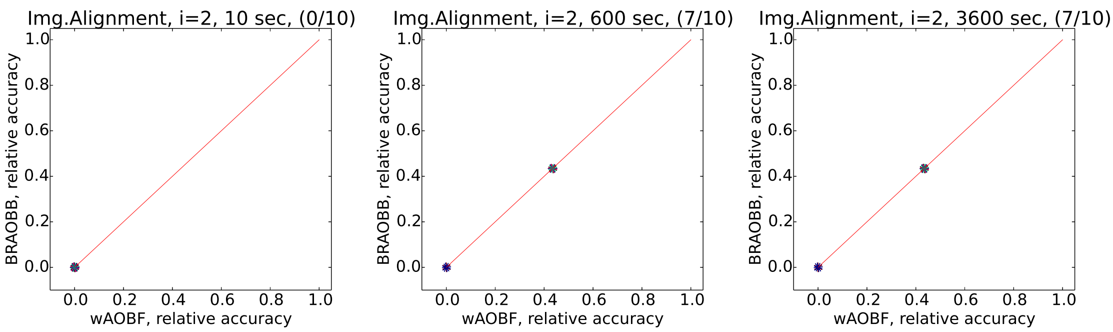
(f) Grids, i=2



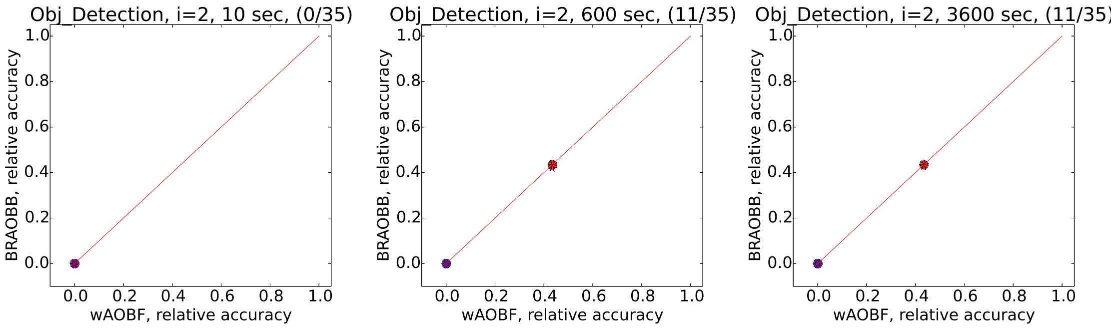
(g) Grids, i=10



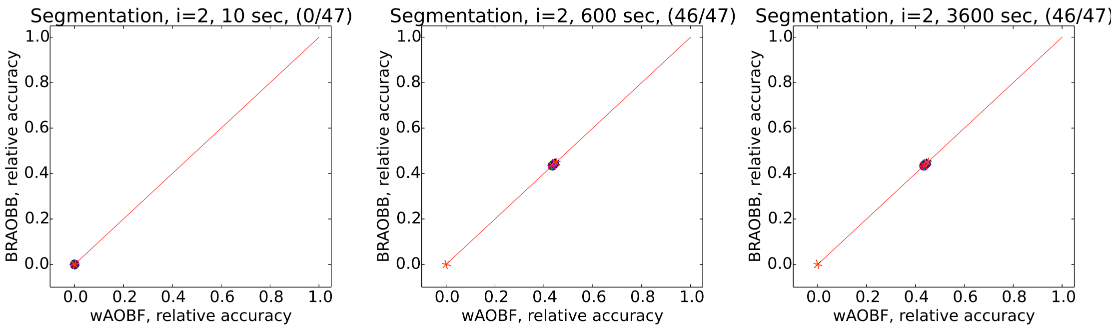
(h) Proteins, i=2



(i) Image Alignment, i=2



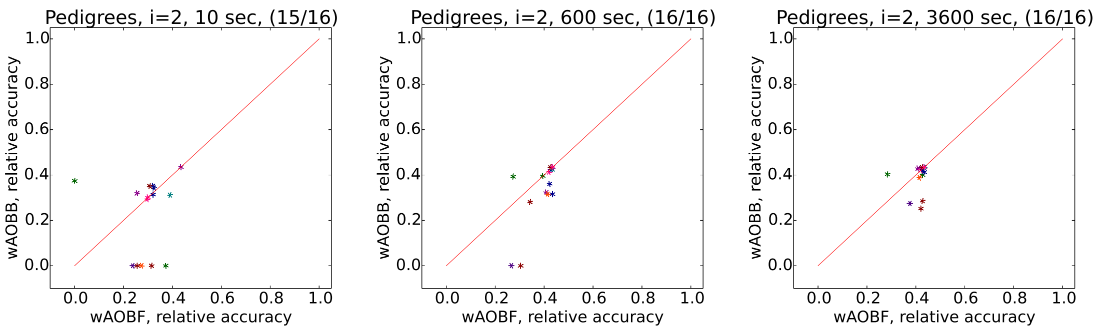
(j) Object Detection, i=2



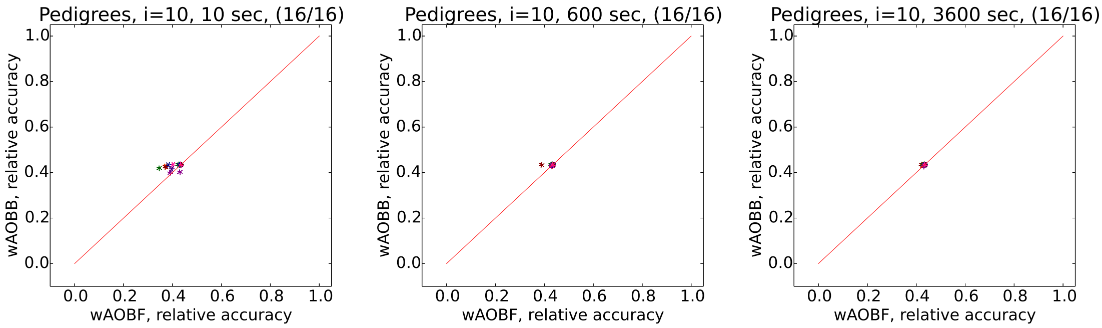
(k) Segmentation, i=2

Figure 9: wAOBF vs BRAOBB with JGLP on all benchmarks. Comparison of relative accuracy at times 10, 600 and 3600 sec. Each row - a single time bound. Each marker represents a single instance. In parenthesis (X/Y): X - # instances, for which at least one algorithm found a solution, Y - total # instances. Only i=2 case is reported for benchmarks where heuristic computation with higher i-bound was infeasible.

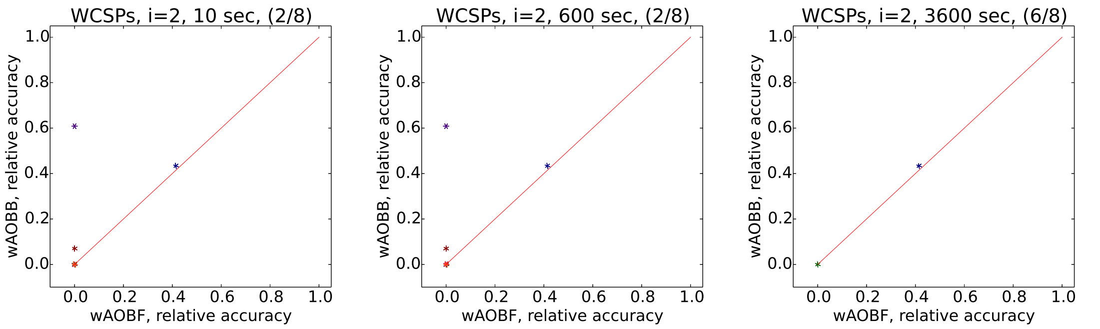
2.3.3 wAOBF vs wAOBB with MBE-MM heuristic



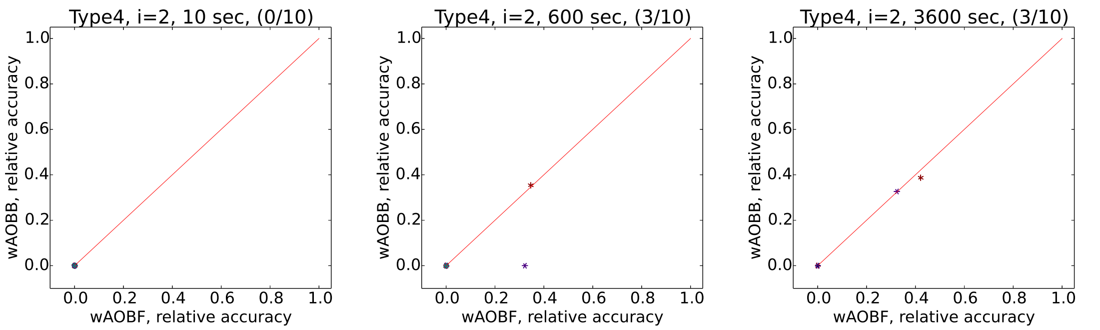
(a) Pedigrees, i=2



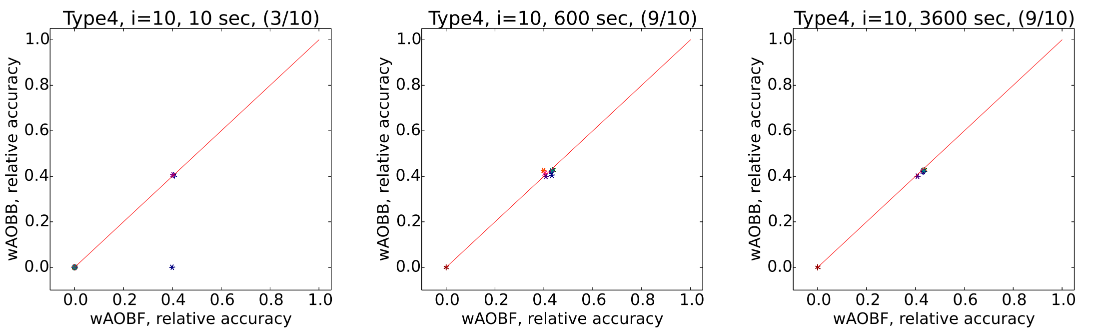
(b) Pedigrees, i=10



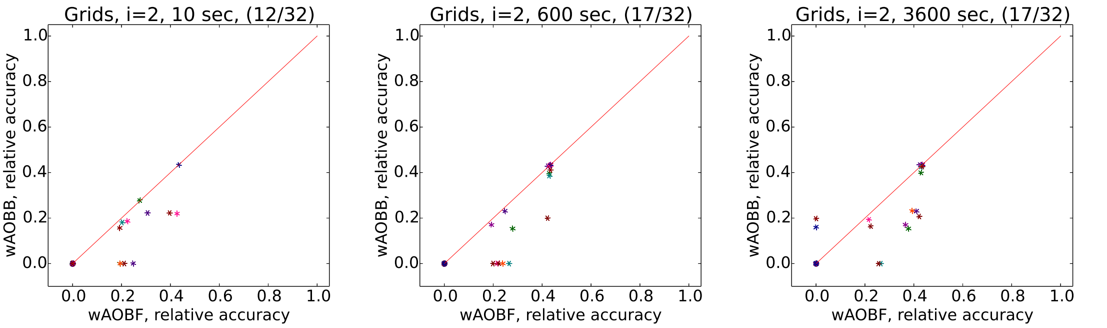
(c) WCSPs, i=2



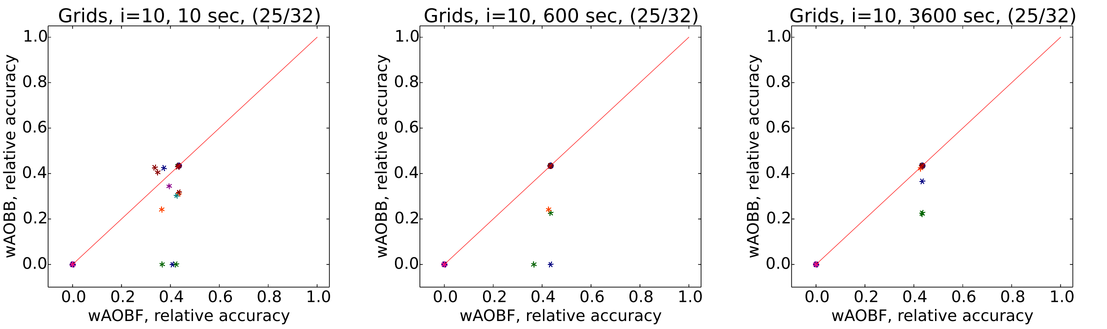
(d) Type4, i=2



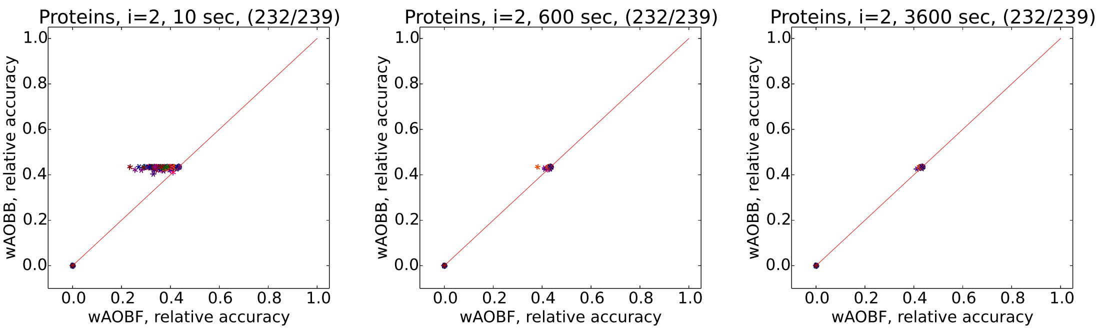
(e) Type4, i=10



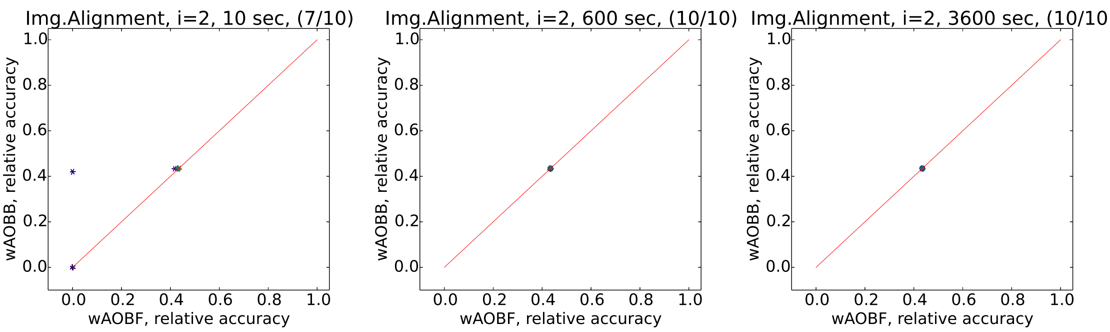
(f) Grids, i=2



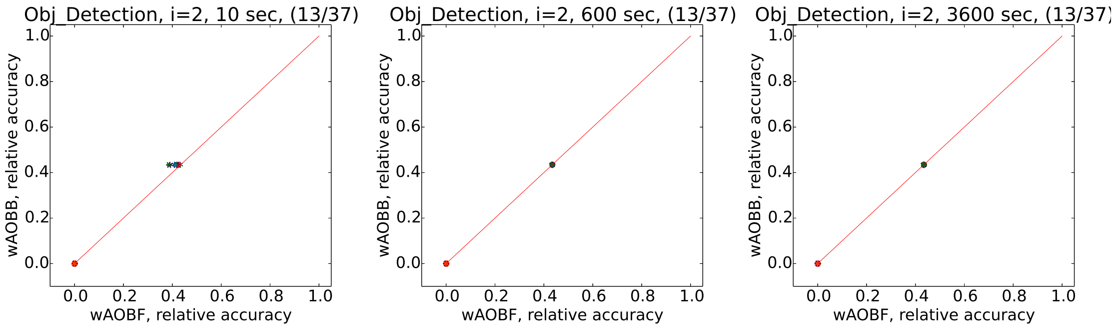
(g) Grids, i=10



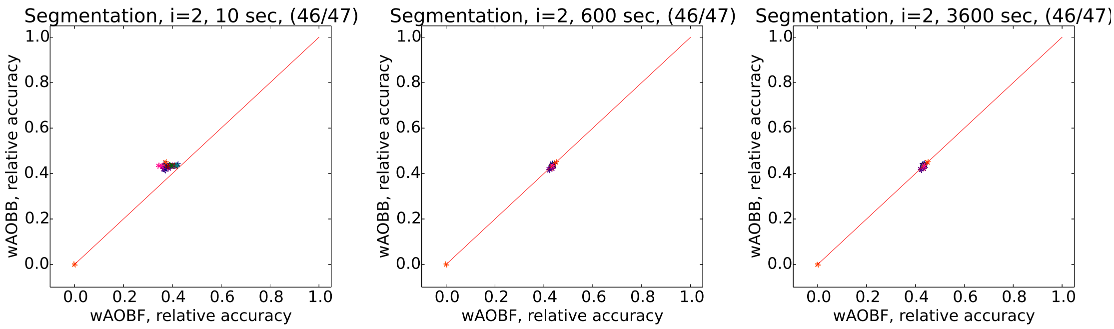
(h) Proteins, i=2



(i) Image Alignment, i=2



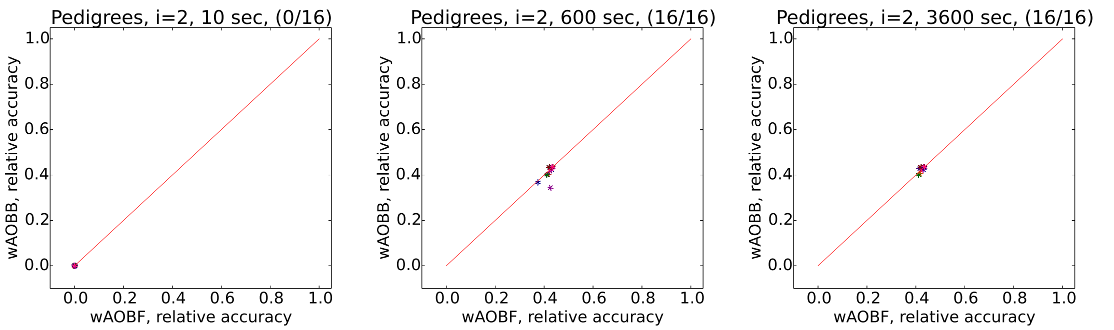
(j) Object Detection, i=2



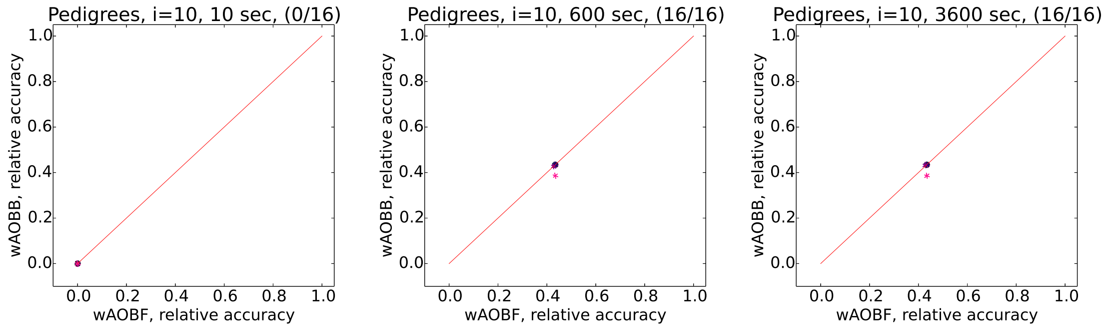
(k) Segmentation, i=2

Figure 10: wAOBF vs wAOBB with MBE-MM on all benchmarks. Comparison of relative accuracy at times 10, 600 and 3600 sec. Each row - a single time bound. Each marker represents a single instance. In parenthesis (X/Y): X - # instances, for which at least one algorithm found a solution, Y - total # instances. Only i=2 case is reported for benchmarks where heuristic computation with higher i-bound was infeasible.

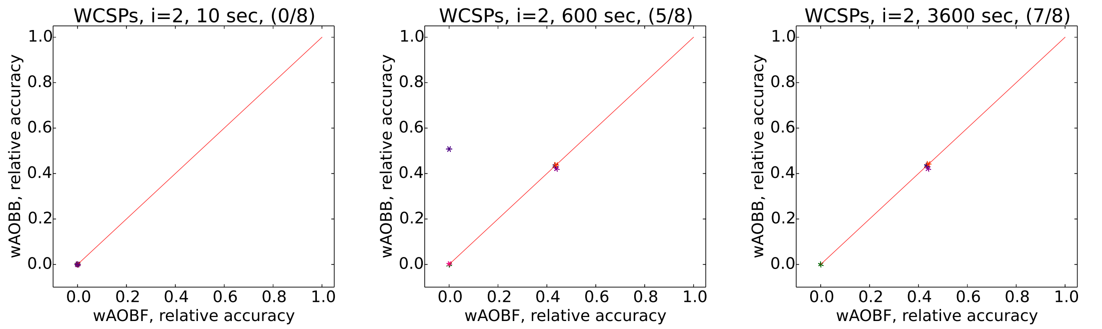
2.3.4 wAOBF vs wAOBB with JGLP heuristic



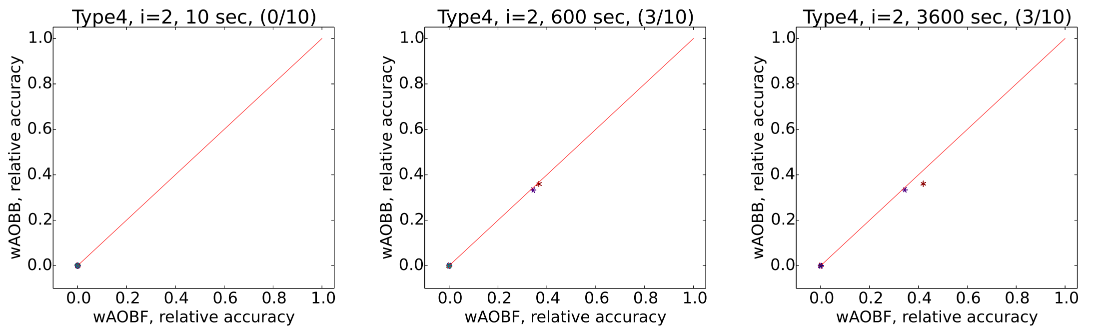
(a) Pedigrees, i=2



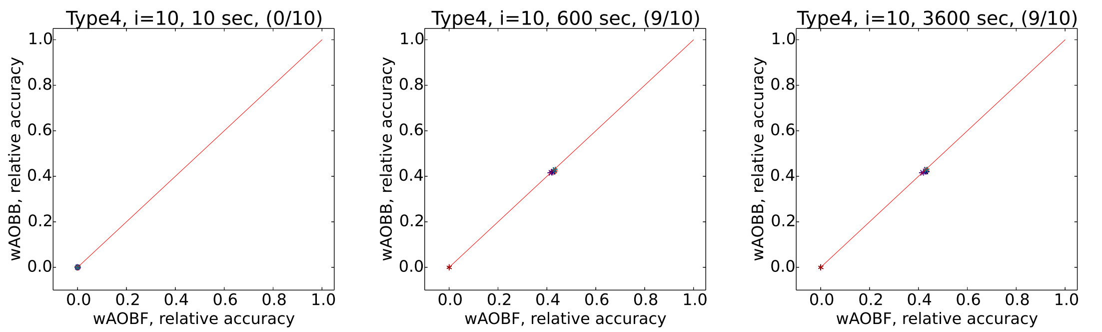
(b) Pedigrees, i=10



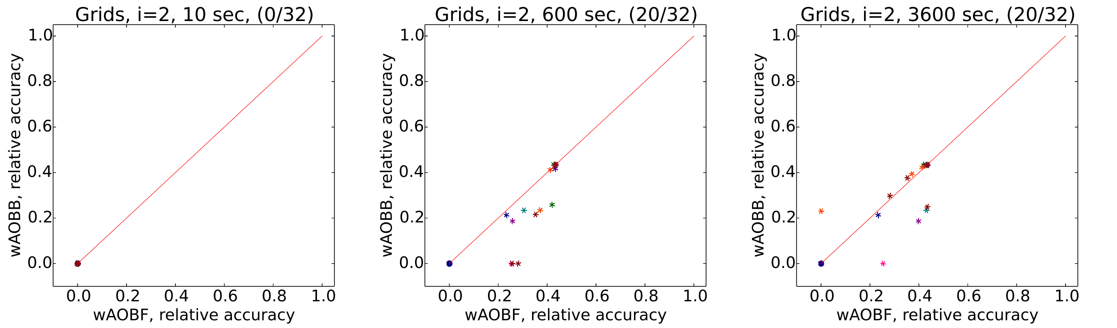
(c) WCSPs, i=2



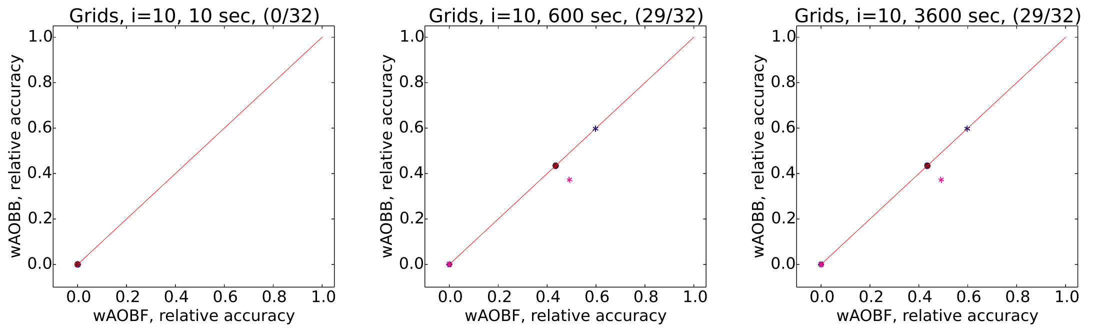
(d) Type4, i=2



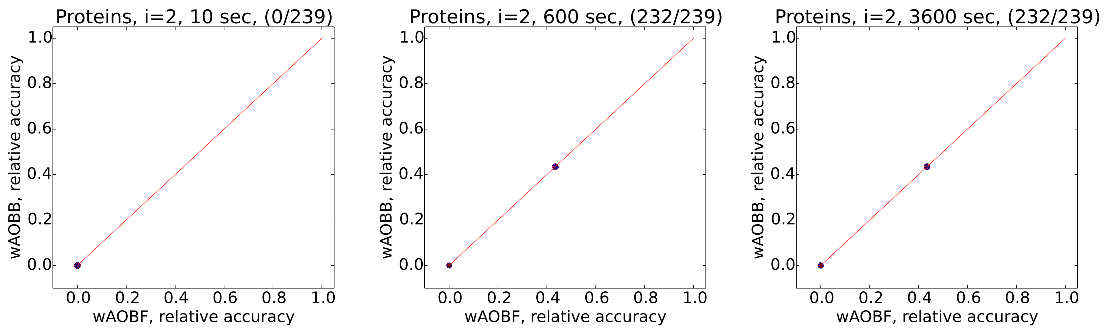
(e) Type4, i=10



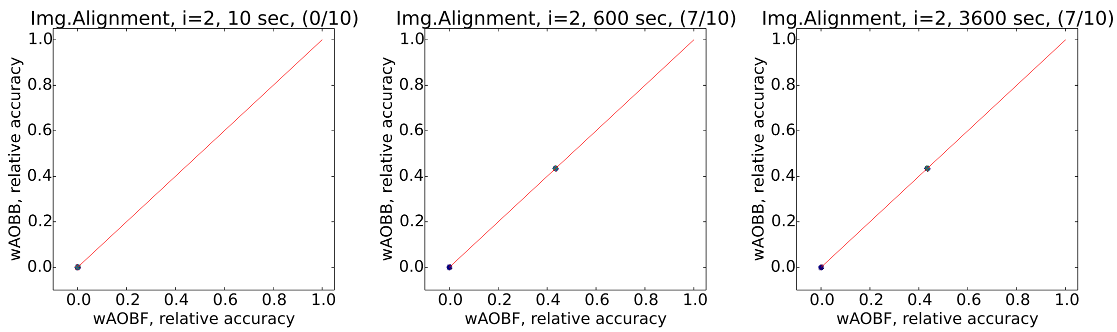
(f) Grids, i=2



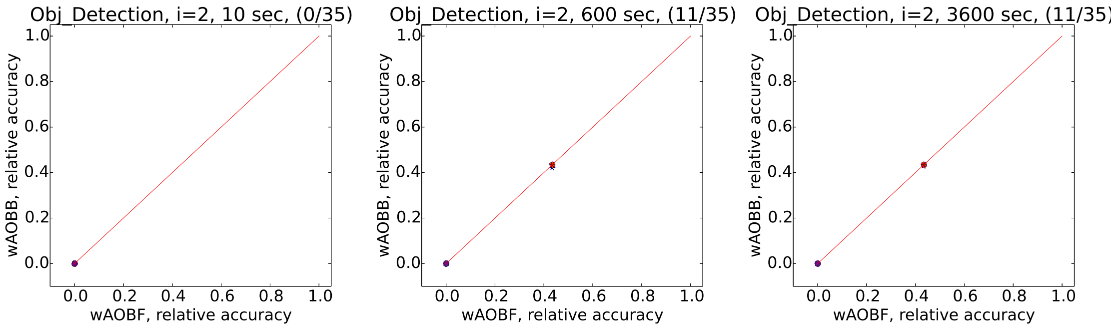
(g) Grids, i=10



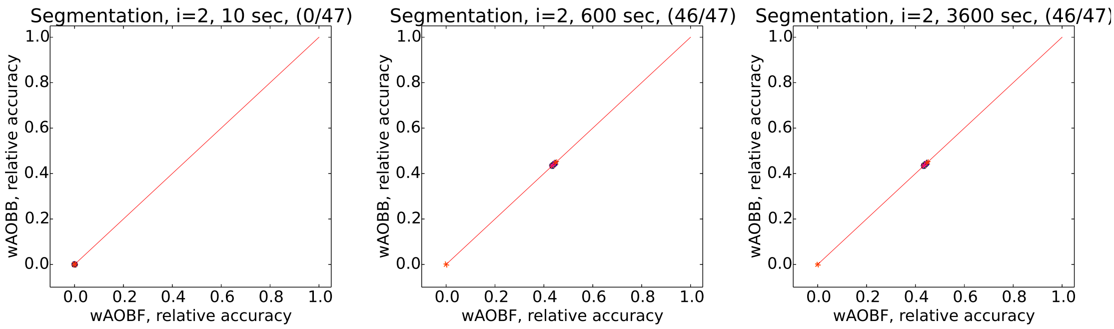
(h) Proteins, i=2



(i) Image Alignment, i=2



(j) Object Detection, i=2



(k) Segmentation, i=2

Figure 11: wAOBF vs wAOBB with JGLP on all benchmarks. Comparison of relative accuracy at times 10, 600 and 3600 sec. Each row - a single time bound. Each marker represents a single instance. In parenthesis (X/Y): X - # instances, for which at least one algorithm found a solution, Y - total # instances. Only i=2 case is reported for benchmarks where heuristic computation with higher i-bound was infeasible.

2.4 Time required for each weighted scheme to reach a particular weight

2.4.1 Using heuristic MBE-MM

Instance	BRAOBB	wAOBF weights			
		2.828	1.139	1.033	1.00
		wAOBF wAOBB wBRAOBB	wAOBF wAOBB wBRAOBB	wAOBF wAOBB wBRAOBB	wAOBF wAOBB wBRAOBB
	time / cost	time / cost	time / cost	time / cost	time / cost
Pedigrees, I-bound=2					
pedigree31 (1006, 5, 29, 115)	21600 / -327.52	6896.65 / -372.2 5.0 / -407.83 8.89 / -407.83	8279.77 / -324.73 55.98 / -331.87 20.51 / -331.31	8279.77 / -324.73 55.98 / -331.87 20.51 / -331.31	8279.77 / -324 .73 55.98 / -331.87 20.51 / -331.31
pedigree33 (581, 4, 24, 132)	21600 / -172.58	414.66 / -213.6 4545.13 / -236.2 4761.11 / -236.2	463.93 / -173.56 4925.16 / -179.17 5150.37 / -175.82	463.93 / -173.56 7741.75 / -175.34 11352.92 / -175.34	463.93 / -173.56 7741.75 / -175.34 11352.92 / -175.34
pedigree37 (726, 5, 20, 72)	698.7 / -333.603	51.63 / -435.99 26.17 / -469.94 51.9 / -469.94	58.31 / -341.46 34.76 / -369.64 63.58 / -366.1	89.4 / -333.6 107.62 / -336.48 152.04 / -334.79	89.4 / -333.6 107.62 / -336.48 152.04 / -334.79
Pedigrees, I-bound=10					
pedigree31 (1006, 5, 29, 115)	21600 / -300.4	105.26 / -322.49 2.87 / -343.0 3.02 / -343.0	114.1 / -306.82 3.11 / -327.5 3.28 / -327.5	194.5 / -300.92 3.95 / -311.17 3.57 / -308.1	194.5 / -300.92 3.95 / -311.17 3.57 / -308.1
pedigree33 (581, 4, 24, 132)	26.0 / -172.576	11.11 / -186.74 1.64 / -181.83 1.89 / -181.83	12.04 / -173.78 1.76 / -181.36 2.03 / -181.36	59.67 / -172.58 3.31 / -179.17 2.26 / -172.58	59.67 / -172.58 3.31 / -179.17 2.26 / -172.58
pedigree37 (726, 5, 20, 72)	0.32 / -333.603	3.93 / -357.9 1.81 / -335.25 1.9 / -335.25	4.25 / -334.69 1.95 / -334.1 2.03 / -334.1	4.87 / -333.6 1.97 / -334.02 2.05 / -334.02	4.87 / -333.6 1.97 / -334.02 2.05 / -334.02
WCSPs, I-bound=2					
404.wcsp (100, 4, 19, 59)	61.38 / -6.402	60.57 / -6.8 60.24 / -7.02 0.24 / -6.8	61.0 / -6.4 60.44 / -6.46 140.65 / -6.46	80.06 / -6.4 61.64 / -6.4 143.41 / -6.4	80.06 / -6.4 61.64 / -6.4 143.41 / -6.4
505.wcsp (240, 4, 21, 75)	21600 / -5.7	18137.11 / -5.7 22.3 / -5.71 29.24 / -5.71	18137.11 / -5.7 22.3 / -5.71 29.24 / -5.71	18137.11 / -5.7 22.3 / -5.71 29.24 / -5.71	18137.11 / -5.7 22.3 / -5.71 29.24 / -5.71
WCSPs, I-bound=10					
404.wcsp (100, 4, 19, 59)	60.5 / -6.402	60.81 / -6.4 60.54 / -6.4 60.55 / -6.4	60.85 / -6.4 60.56 / -6.4 60.56 / -6.4	61.85 / -6.4 60.58 / -6.4 60.58 / -6.4	61.85 / -6.4 60.58 / -6.4 60.58 / -6.4
505.wcsp (240, 4, 21, 75)	21600 / -5.7	9.77 / -5.7 5.46 / -5.7 5.52 / -5.7	375.72 / -5.7 6.59 / -5.7 3720.37 / -5.7	375.72 / -5.7 6.59 / -5.7 3720.37 / -5.7	375.72 / -5.7 6.59 / -5.7 3720.37 / -5.7
Type4, I-bound=10					
type4b_100_16 (3907, 5, 30, 453)	21600 / -2824.17	95.64 / -2882.61 46.52 / -2941.7 55.04 / -2941.7	103.88 / -2826.88 49.62 / -2860.88 58.78 / -2860.88	107.74 / -2779.06 49.81 / -2856.73 64.34 / -2848.27	107.74 / -2779.06 49.81 / -2856.73 64.34 / -2848.27
type4b_100_19 (3938, 5, 29, 354)	21600 / -2636.28	183.74 / -2732.68 1153.95 / -2732.67 5947.27 / -2732.67	206.46 / -2620.0 1243.47 / -2690.56 6401.44 / -2690.56	226.7 / -2602.31 1249.27 / -2686.5 6465.33 / -2675.81	226.7 / - 2602.31 1249.27 / -2686.5 6465.33 / -2675.81
type4b_120_17 (4072, 5, 24, 319)	21600 / -3126.97	119.62 / -3183.07 42.5 / -3249.82 59.95 / -3249.82	128.17 / -3113.03 45.52 / -3178.29 64.3 / -3178.29	129.55 / -3086.95 45.71 / -3171.97 64.9 / -3161.12	129.55 / -3086.95 45.71 / -3171.97 64.9 / -3161.12

Instance	BRAOBB	**wAOBF weights** 2.828 wAOBF wAOBB wBRAOBB	 1.139 wAOBF wAOBB wBRAOBB	 1.033 wAOBF wAOBB wBRAOBB	 1.00 wAOBF wAOBB wBRAOBB
	time / cost	time / cost	time / cost	time / cost	time / cost
Grids, I-bound=2					
75-18-5 (324, 2, 24, 85)	10119.9 / -20.518	136.5 / -28.49 221.87 / -35.24 686.72 / -36.0	314.23 / -20.74 3313.62 / -20.93 5115.94 / -20.93	314.23 / -20.74 3313.62 / -20.93 10291.87 / -20.52	314.23 / -20.74 3313.62 / -20.93 10291.87 / -20.52
75-19-5 (361, 2, 26, 95)	21600 / -26.91	889.04 / -34.64 9992.59 / -39.57 21331.35 / -49.15	1080.68 / -27.58 13537.28 / -28.1 21331.35 / -49.15	1080.68 / -27.58 13537.28 / -28.1 21331.35 / -49.15	1080.68 / -27.58 13537.28 / -28.1 21331.35 / -49.15
75-20-5 (400, 2, 27, 99)	21600 / -30.58	2643.51 / -38.05 18184.92 / -54.92 16567.12 / -54.92	3181.39 / -32.35 18184.92 / -54.92 16567.12 / -54.92	3181.39 / -32.35 18184.92 / -54.92 16567.12 / -54.92	3181.39 / -32.35 18184.92 / -54.92 16567.12 / -54.92
Grids, I-bound=10					
75-18-5 (324, 2, 24, 85)	0.61 / -20.518	1.43 / -20.98 0.73 / -21.31 0.75 / -21.31	1.54 / -20.98 0.8 / -21.31 0.81 / -21.31	2.16 / -20.52 0.81 / -20.74 0.82 / -20.74	2.16 / -20.52 0.81 / -20.74 0.82 / -20.74
75-19-5 (361, 2, 26, 95)	4.6 / -26.069	4.1 / -28.29 1.06 / -37.66 1.11 / -37.66	4.51 / -27.04 1.18 / -28.73 1.29 / -28.67	5.81 / -26.07 1.47 / -26.17 1.7 / -26.61	5.81 / -26.07 1.47 / -26.17 1.7 / -26.61
75-20-5 (400, 2, 27, 99)	14.03 / -29.288	2.15 / -32.41 1.06 / -33.49 1.06 / -33.49	2.61 / -29.96 1.14 / -33.49 1.15 / -32.62	8.53 / -29.29 1.71 / -29.54 2.37 / -29.54	8.53 / -29.29 1.71 / -29.54 2.37 / -29.54
Proteins, I-bound=2					
pdb1aly (122, 81, 10, 34)	1.05 / -173.719	10.2 / -176.09 0.8 / -185.04 0.8 / -185.04	11.54 / -176.09 0.85 / -178.88 0.85 / -178.88	29.92 / -173.72 0.85 / -178.88 0.86 / -178.88	29.92 / -173.72 0.85 / -178.88 0.86 / -178.88
pdb1iqz (67, 81, 7, 25)	0.04 / -66.112	2.43 / -68.1 0.3 / -69.22 0.3 / -69.22	2.63 / -68.1 0.32 / -68.1 0.32 / -68.1	2.7 / -66.11 0.33 / -66.37 0.33 / -66.37	2.7 / -66.11 0.33 / -66.37 0.33 / -66.37
pdb2eif (112, 81, 8, 29)	147.1 / -119.126	11.16 / -120.61 0.82 / -122.03 0.84 / -122.03	73.1 / -119.13 0.87 / -122.03 0.88 / -122.03	284.13 / -119.13 18.02 / -120.55 19.09 / -120.55	284.13 / -119.13 18.02 / -120.55 19.09 / -120.55
Img.Alignment, I-bound=2					
fileforGal_150markers (150, 93, 17, 67)	2.33 / -4671.93	72.97 / -4671.93 5.23 / -4671.93 5.79 / -4671.93	78.64 / -4671.93 5.46 / -4671.93 6.07 / -4671.93	79.94 / -4671.93 5.49 / -4671.93 6.12 / -4671.93	79.94 / -4671.93 5.49 / -4671.93 6.12 / -4671.93
fileforGal_200markers (200, 69, 22, 86)	3.92 / -7476.359	143.05 / -7483.42 9.16 / -7488.46 8.88 / -7488.46	154.91 / -7476.36 9.63 / -7476.36 9.29 / -7476.36	158.93 / -7476.36 9.69 / -7476.36 9.34 / -7476.36	15 8.93 / -7476.36 9.69 / -7476.36 9.34 / -7476.36
fileforGal_250markers (250, 60, 20, 106)	5.12 / -7290.592	144.12 / -7297.29 10.06 / -7304.02 10.83 / -7304.02	155.25 / -7290.59 10.47 / -7290.59 11.29 / -7290.59	357.66 / -7290.59 10.53 / -7290.59 11.36 / -7290.59	3 57.66 / -7290.59 10.53 / -7290.59 11.36 / -7290.59
Object Detection, I-bound=2					
deer_rescaled_3020 .K20.F100.model (60, 21, 59, 59)	5664.17 / -2978.32	132.81 / -3005.67 7.8 / -2999.95 7.6 / -2999.95	144.78 / -2978.32 8.37 / -2978.32 8.13 / -2978.32	154.28 / -2978.32 8.44 / -2978.32 8.2 / -2978.32	154.28 / -2978.32 8.44 / -2978.32 8.2 / -2978.32
giraffe_rescaled_3016 .K10.F100.model (60, 11, 59, 59)	21600 / -12342.66	34.67 / -12127.59 3.78 / -12156.21 3.68 / -12156.21	44.78 / -12118.96 4.06 / -12118.96 3.95 / -12118.96	44.7 8 / -12118.96 4.06 / -12118.96 3.95 / -12118.96	44.78 / -12118.96 4.06 / -12118.96 3.95 / -12118.96
giraffe_rescaled_3016 .K15.F100.model (60, 16, 59, 59)	21600 / -9105.76	78.21 / -9377.91 5.78 / -9141.58 5.68 / -9141.58	168.77 / -9105.76 6.21 / -9141.58 6.09 / -9141.58	168.77 / -9105.76 6.21 / -9141.58 6.09 / -9141.58	168.77 / -9105.76 6.21 / -9141.58 6.09 / -9141.58

Instance	BRAOBB	wAOBF weights			
		2.828	1.139	1.033	1.00
		wAOBF wAOBB wBRAOBB	wAOBF wAOBB wBRAOBB	wAOBF wAOBB wBRAOBB	wAOBF wAOBB wBRAOBB
	time / cost	time / cost	time / cost	time / cost	time / cost
Segmentation, I-bound=2					
12_4_s.21 (224, 21, 16, 48)	21600 / -268.29	18.27 / -275.18 1.8 / -272.9 1.83 / -272.9	19.78 / -268.29 1.93 / -270.31 1.94 / -270.31	22.93 / -268.29 1.98 / -270.31 1.98 / -269.0	22.93 / -268.29 1.98 / -270.31 1.98 / -269.0
14_26_s.21 (228, 21, 15, 53)	21600 / -292.4	18.63 / -309.93 1.85 / -303.75 1.88 / -303.75	20.16 / -295.57 1.97 / -294.19 2.01 / -294.19	24.35 / -293.17 1.99 / -292.45 2.03 / -292.45	24.35 / -293.17 1.99 / -292.45 2.03 / -292.45
15_3_s.21 (231, 21, 16, 57)	21600 / -324.99	19.64 / -331.19 1.93 / -348.66 1.95 / -348.66	21.98 / -331.19 2.07 / -340.01 2.08 / -340.01	22.97 / -326.3 2.1 / -330.79 2.11 / -332.24	22.97 / -326.3 2.1 / -330.79 2.11 / -332.24

Table 1: Runtime (sec) and cost obtained by wAOBF, wAOBB and wBRAOBB for selected w, and by BRAOBB (that finds C^* - optimal cost). Instance parameters: n - number of variables, k - max domain size, w^* - induced width, h_T - pseudo tree height.

2.4.2 Using heuristic JGLP

Instance	BRAOBB	wAOBF weights			
		2.828	1.139	1.033	1.00
		wAOBF wAOBB wBRAOBB	wAOBF wAOBB wBRAOBB	wAOBF wAOBB wBRAOBB	wAOBF wAOBB wBRAOBB
	time / cost	time / cost	time / cost	time / cost	time / cost
Pedigrees, I-bound=2					
pedigree31 (1006, 5, 29, 115)	21600 / -314.67	67.99 / -347.83 63.78 / -353.8 64.92 / -353.8	72.55 / -317.01 64.3 / -331.26 65.78 / -335.65	88.3 / -317.01 66.81 / -325.8 10669.92 / -317.01	88.3 / -317.01 66.81 / -325.8 10669.92 / -317.01
pedigree33 (581, 4, 24, 132)	21600 / -172.58	63.84 / -194.47 61.83 / -204.86 61.72 / -204.86	65.31 / -175.18 62.11 / -181.27 62.18 / -181.27	65.31 / -175.18 11748.92 / -172.58 600.2 / -172.58	65.31 / -175.18 11748.92 / -172.58 600.2 / -172.58
pedigree37 (726, 5, 20, 72)	243.79 / -333.603	63.79 / -345.25 61.88 / -360.29 61.95 / -360.29	64.11 / -335.9 62.03 / -339.86 62.11 / -339.86	201.19 / -333.6 62.06 / -335.06 62.13 / -335.06	201.19 / -333.6 62.06 / -335.06 62.13 / -335.06
Pedigrees, I-bound=10					
pedigree31 (1006, 5, 29, 115)	11936.54 / -300.398	67.19 / -313.25 63.65 / -325.54 63.6 / -325.54	67.74 / -310.9 63.89 / -325.54 63.83 / -325.54	67.86 / -302.52 63.92 / -312.36 63.87 / -312.36	67.86 / -302.52 63.92 / -312.36 63.87 / -312.36
pedigree33 (581, 4, 24, 132)	68.96 / -172.576	63.83 / -172.8 61.96 / -172.8 62.01 / -172.8	64.12 / -172.8 62.09 / -172.8 62.14 / -172.8	83.43 / -172.58 62.12 / -172.8 62.16 / -172.8	83.43 / -172.58 62.12 / -172.8 62.16 / -172.8
pedigree37 (726, 5, 20, 72)	61.46 / -333.603	64.94 / -334.66 63.1 / -334.66 63.29 / -334.66	65.22 / -334.66 63.24 / -334.66 63.44 / -334.66	65.48 / -333.6 63.26 / -334.66 63.46 / -334.66	65.48 / -333.6 63.26 / -334.66 63.46 / -334.66

Instance	BRAOBB	**wAOBF weights**			
		2.828	1.139	1.033	1.00
		wAOBF wAOBB wBRAOBB	wAOBF wAOBB wBRAOBB	wAOBF wAOBB wBRAOBB	wAOBF wAOBB wBRAOBB
	time / cost	time / cost	time / cost	time / cost	time / cost
WCSPs, I-bound=2					
404.wcsp (100, 4, 19, 59)	61.32 / -6.402	60.51 / -6.8 60.21 / -7.02 60.23 / -7.02	60.89 / -6.4 60.39 / -6.46 60.61 / -6.46	77.82 / -6.4 61.45 / -6.4 62.83 / -6.4	77.82 / -6.4 61.45 / -6.4 62.83 / -6.4
505.wcsp (240, 4, 21, 75)	21600 / -5.7	63.73 / -5.7 61.16 / -5.7 61.2 / -5.97	326.93 / -5.7 413.16 / -5.7 522.89 / -5.7	326.93 / -5.7 413.16 / -5.7 522.89 / -5.7	326.93 / -5.7 413.16 / -5.7 522.89 / -5.7
WCSPs, I-bound=10					
404.wcsp (100, 4, 19, 59)	60.55 / -6.402	60.73 / -6.4 60.56 / -6.4 60.55 / -6.4	60.76 / -6.4 60.57 / -6.4 60.57 / -6.4	61.65 / -6.4 60.59 / -6.4 60.58 / -6.4	61.65 / -6.4 60.59 / -6.4 60.58 / -6.4
Type4, I-bound=10					
type4b_100_16 (3907, 5, 30, 453)	21600 / -2804.69	155.53 / -2842.0 109.81 / -2851.11 119.77 / -2851.11	162.31 / -2828.31 113.11 / -2850.21 123.88 / -2850.21	164.49 / -2799.9 113.34 / -2836.05 124.47 / -2813.2	164.49 / -2799.9 113.34 / -2836.05 124.47 / -2813.2
type4b_100_19 (3938, 5, 29, 354)	21600 / -2628.07	577.33 / -2644.55 164.19 / -2684.76 617.98 / -2684.76	601.62 / -2627.46 172.44 / -2679.86 661.27 / -2679.59	603.81 / -2607.9 173.03 / -2679.86 667.11 / -2674.43	603.81 / -2607.9 173.03 / -2679.86 667.11 / -2674.43
type4b_120_17 (4072, 5, 24, 319)	21600 / -3083.34	150.74 / -3117.41 131.27 / -3123.71 167.97 / -3123.71	158.13 / -3109.83 136.37 / -3121.15 175.72 / -3121.15	159.19 / -3092.69 136.7 / -3121.0 176.76 / -3113.69	159.19 / -3092.69 136.7 / -3121.0 176.76 / -3113.69
Grids, I-bound=2					
75-18-5 (324, 2, 24, 85)	287.75 / -20.518	62.08 / -22.91 60.98 / -21.74 61.11 / -21.74	62.54 / -20.52 61.07 / -21.21 61.21 / -21.21	64.82 / -20.52 61.08 / -20.9 61.22 / -20.9	64.82 / -20.52 61.08 / -20.9 61.22 / -20.9
75-19-5 (361, 2, 26, 95)	13505.42 / -26.069	66.49 / -28.44 66.32 / -35.09 76.56 / -35.55	68.15 / -28.22 66.98 / -29.97 78.08 / -29.91	229.71 / -26.17 839.89 / -26.3 1958.73 / -26.07	229.71 / -26.17 839.89 / -26.3 1958.73 / -26.07
75-20-5 (400, 2, 27, 99)	21600 / -30.58	246.14 / -37.58 287.36 / -44.06 780.34 / -44.06	346.8 / -30.79 459.56 / -30.88 1364.56 / -30.88	346.8 / -30.79 459.56 / -30.88 1364.56 / -30.88	346.8 / -30.79 459.56 / -30.88 1364.56 / -30.88
Grids, I-bound=10					
75-18-5 (324, 2, 24, 85)	60.13 / -20.518	61.72 / -20.52 60.81 / -20.52 60.84 / -20.52	61.84 / -20.52 60.88 / -20.52 60.91 / -20.52	61.87 / -20.52 60.88 / -20.52 60.92 / -20.52	61.87 / -20.52 60.88 / -20.52 60.92 / -20.52
75-19-5 (361, 2, 26, 95)	60.17 / -26.069	62.18 / -26.69 60.96 / -31.39 60.99 / -31.39	62.34 / -26.45 61.03 / -26.91 61.05 / -26.91	62.41 / -26.07 61.04 / -26.45 61.07 / -26.45	62.41 / -26.07 61.04 / -26.45 61.07 / -26.45
75-20-5 (400, 2, 27, 99)	60.19 / -29.288	62.3 / -29.29 61.09 / -29.29 61.13 / -29.29	62.47 / -29.29 61.16 / -29.29 61.21 / -29.29	62.5 / -29.29 61.18 / -29.29 61.22 / -29.29	62.5 / -29.29 61.18 / -29.29 61.22 / -29.29
Proteins, I-bound=2					
pdb1aly (122, 81, 10, 34)	60.88 / -173.719	70.2 / -173.72 61.53 / -173.72 61.53 / -173.72	70.99 / -173.72 61.58 / -173.72 61.59 / -173.72	71.76 / -173.72 61.58 / -173.72 61.59 / -173.72	71.76 / -173.72 61.58 / -173.72 61.59 / -173.72
pdb1iqz (67, 81, 7, 25)	60.16 / -66.112	63.14 / -66.11 60.41 / -66.11 60.43 / -66.11	63.38 / -66.11 60.43 / -66.11 60.45 / -66.11	63.45 / -66.11 60.43 / -66.11 60.45 / -66.11	63.45 / -66.11 60.43 / -66.11 60.45 / -66.11
pdb2eif (112, 81, 8, 29)	61.12 / -119.126	71.22 / -121.43 61.79 / -121.43 61.78 / -121.43	72.04 / -121.43 61.84 / -121.43 61.83 / -121.43	72.76 / -119.13 61.84 / -121.43 61.84 / -121.43	72.76 / -119.13 61.84 / -121.43 61.84 / -121.43

Instance	BRAOBB	wAOBF weights			
		2.828	1.139	1.033	1.00
		wAOBF wAOBB wBRAOBB	wAOBF wAOBB wBRAOBB	wAOBF wAOBB wBRAOBB	wAOBF wAOBB wBRAOBB
	time / cost	time / cost	time / cost	time / cost	time / cost
Img.Alignment, I-bound=2					
fileforGal_150markers (150, 93, 17, 67)	70.98 / -4671.93	155.46 / -4671.93 74.18 / -4671.93 74.03 / -4671.93	162.22 / -4671.93 74.44 / -4671.93 74.28 / -4671.93	163.61 / -4671.93 74.48 / -4671.93 74.31 / -4671.93	16 3.61 / -4671.93 74.48 / -4671.93 74.31 / -4671.93
fileforGal_200markers (200, 69, 22, 86)	79.15 / -7476.359	244.79 / -7476.36 85.04 / -7476.36 84.6 / -7476.36	258.35 / -7476.36 85.56 / -7476.36 85.06 / -7476.36	261.54 / -7476.36 85.63 / -7476.36 85.11 / -7476.36	2 61.54 / -7476.36 85.63 / -7476.36 85.11 / -7476.36
fileforGal_250markers (250, 60, 20, 106)	86.05 / -7290.592	259.53 / -7292.77 92.19 / -7292.77 92.23 / -7292.77	273.49 / -7290.59 92.68 / -7290.59 92.73 / -7290.59	279.94 / -7290.59 92.74 / -7290.59 92.8 / -7290.59	279.94 / -7290.59 92.74 / -7290.59 92.8 / -7290.59
Object Detection, I-bound=2					
deer_rescaled_3020 .K20.F100.model (60, 21, 59, 59)	64.12 / -2978.32	171.59 / -2981.03 67.81 / -2978.32 67.9 / -2978.32	180.31 / -2978.32 68.23 / -2978.32 68.33 / -2978.32	181.99 / -2978.32 68.28 / -2978.32 68.39 / -2978.32	181.99 / -2978.32 68.28 / -2978.32 68.39 / -2978.32
giraffe_rescaled_3016 .K10.F100.model (60, 11, 59, 59)	399.56 / -12118.963	88.23 / -12118.96 63.17 / -12118.96 63.14 / -12118.96	90.48 / -12118.96 63.39 / -12118.96 63.35 / -12118.96	99. 39 / -12118.96 63.42 / -12118.96 63.37 / -12118.96	99.39 / -12118.96 63.42 / -12118.96 63.37 / -12118.96
giraffe_rescaled_3016 .K15.F100.model (60, 16, 59, 59)	2954.53 / -9013.297	121.26 / -9013.3 65.3 / -9013.3 65.23 / -9013.3	126.24 / -9013.3 65.62 / -9013.3 65.54 / -9013.3	152.1 / -9013.3 65.67 / -9013.3 65.58 / -9013.3	152.1 / -9013.3 65.67 / -9013.3 65.58 / -9013.3
Segmentation, I-bound=2					
12_4_s.21 (224, 21, 16, 48)	61.19 / -268.292	80.46 / -268.29 62.7 / -268.29 62.75 / -268.29	82.0 / -268.29 62.83 / -268.29 62.87 / -268.29	82.47 / -268.29 62.84 / -268.29 62.88 / -268.29	82.47 / -268.29 62.84 / -268.29 62.88 / -268.29
14_26_s.21 (228, 21, 15, 53)	61.22 / -292.399	80.47 / -292.63 62.78 / -292.63 62.8 / -292.63	82.04 / -292.56 62.9 / -292.56 62.93 / -292.56	82.84 / -292.4 62.92 / -292.56 62.95 / -292.56	82.84 / -292.4 62.92 / -292.56 62.95 / -292.56
15_3_s.21 (231, 21, 16, 57)	61.32 / -319.384	82.14 / -320.03 62.94 / -320.03 62.99 / -320.03	83.83 / -320.03 63.08 / -320.03 63.13 / -320.03	84.78 / -319.38 63.1 / -320.03 63.15 / -320.03	84.78 / -319.38 63.1 / -320.03 63.15 / -320.03

Table 2: Runtime (sec) and cost obtained by wAOBF, wAOBB and wBRAOBB for selected w, and by BRAOBB (that finds C^* - optimal cost). Instance parameters: n - number of variables, k - max domain size, w^* - induced width, h_T - pseudo tree height.

2.5 Summary

2.5.1 MBE-MM heuristic

I-bound	Algorithm	Time bounds				
		10	30	600	3600	21600
		X% / Y% / N	X% / Y% / N	X% / Y% / N	X% / Y% / N	X% / Y% / N
Pedigrees (# inst=16, $n = 298 - 1015, k = 3 - 7, w^* = 15 - 33, h_T = 59 - 140$						
i=2	wAOBF	68.8 / 6.3 / 16	56.3 / 6.3 / 16	62.5 / 6.3 / 16	43.8 / 12.5 / 16	31.3 / 12.5 / 16
	wR-AOBF	25.0 / 6.3 / 16	50.0 / 6.3 / 16	37.5 / 6.3 / 16	25.0 / 6.3 / 16	12.5 / 6.3 / 16
	wAOBB	37.5 / 37.5 / 16	31.3 / 31.3 / 16	31.3 / 31.3 / 16	37.5 / 25.0 / 16	37.5 / 37.5 / 16
i=4	wAOBF	26.7 / 6.7 / 15	31.3 / 25.0 / 16	37.5 / 25.0 / 16	25.0 / 25.0 / 16	18.8 / 25.0 / 16
	wR-AOBF	20.0 / 6.7 / 15	25.0 / 18.8 / 16	25.0 / 18.8 / 16	18.8 / 18.8 / 16	6.3 / 18.8 / 16
	wAOBB	13.3 / 46.7 / 15	6.3 / 62.5 / 16	31.3 / 50.0 / 16	25.0 / 62.5 / 16	12.5 / 62.5 / 16
i=6	wAOBF	18.8 / 18.8 / 16	31.3 / 31.3 / 16	18.8 / 43.8 / 16	31.3 / 43.8 / 16	18.8 / 43.8 / 16
	wR-AOBF	18.8 / 25.0 / 16	25.0 / 37.5 / 16	18.8 / 43.8 / 16	18.8 / 43.8 / 16	12.5 / 43.8 / 16
	wAOBB	25.0 / 43.8 / 16	31.3 / 50.0 / 16	18.8 / 68.8 / 16	18.8 / 75.0 / 16	12.5 / 81.3 / 16
i=8	wAOBF	25.0 / 25.0 / 16	31.3 / 31.3 / 16	25.0 / 37.5 / 16	12.5 / 50.0 / 16	12.5 / 50.0 / 16
	wR-AOBF	12.5 / 25.0 / 16	37.5 / 31.3 / 16	18.8 / 43.8 / 16	12.5 / 43.8 / 16	6.3 / 43.8 / 16
	wAOBB	12.5 / 43.8 / 16	18.8 / 56.3 / 16	25.0 / 62.5 / 16	18.8 / 68.8 / 16	12.5 / 81.3 / 16
i=10	wAOBF	6.3 / 37.5 / 16	12.5 / 62.5 / 16	6.3 / 62.5 / 16	6.3 / 62.5 / 16	6.3 / 62.5 / 16
	wR-AOBF	18.8 / 43.8 / 16	12.5 / 56.3 / 16	6.3 / 56.3 / 16	6.3 / 56.3 / 16	0.0 / 56.3 / 16
	wAOBB	12.5 / 62.5 / 16	6.3 / 75.0 / 16	12.5 / 87.5 / 16	6.3 / 93.8 / 16	0.0 / 93.8 / 16
i=14	wAOBF	14.3 / 50.0 / 14	14.3 / 64.3 / 14	7.1 / 64.3 / 14	0.0 / 64.3 / 14	0.0 / 64.3 / 14
	wR-AOBF	7.1 / 57.1 / 14	0.0 / 64.3 / 14	0.0 / 57.1 / 14	0.0 / 57.1 / 14	0.0 / 57.1 / 14
	wAOBB	0.0 / 92.9 / 14	0.0 / 100.0 / 14	0.0 / 100.0 / 14	0.0 / 92.9 / 14	0.0 / 100.0 / 14
i=18	wAOBF	0.0 / 50.0 / 12	0.0 / 66.7 / 12	0.0 / 66.7 / 12	0.0 / 66.7 / 12	0.0 / 66.7 / 12
	wR-AOBF	0.0 / 58.3 / 12	0.0 / 66.7 / 12	0.0 / 66.7 / 12	0.0 / 66.7 / 12	0.0 / 66.7 / 12
	wAOBB	0.0 / 91.7 / 12	0.0 / 100.0 / 12	0.0 / 100.0 / 12	0.0 / 100.0 / 12	0.0 / 100.0 / 12
WCSPs (# inst=8, $n = 100 - 665, k = 2 - 3, w^* = 19 - 89, h_T = 45 - 287$						
i=2	wAOBF	16.7 / 0.0 / 6	0.0 / 12.5 / 8	0.0 / 12.5 / 8	0.0 / 25.0 / 8	0.0 / 25.0 / 8
	wR-AOBF	0.0 / 0.0 / 6	0.0 / 25.0 / 8	0.0 / 25.0 / 8	0.0 / 25.0 / 8	0.0 / 25.0 / 8
	wAOBB	33.3 / 16.7 / 6	12.5 / 25.0 / 8	0.0 / 25.0 / 8	0.0 / 25.0 / 8	25.0 / 37.5 / 8
i=4	wAOBF	33.3 / 16.7 / 6	16.7 / 16.7 / 6	0.0 / 33.3 / 6	16.7 / 33.3 / 6	16.7 / 33.3 / 6
	wR-AOBF	33.3 / 16.7 / 6	16.7 / 33.3 / 6	16.7 / 33.3 / 6	16.7 / 33.3 / 6	16.7 / 33.3 / 6
	wAOBB	33.3 / 33.3 / 6	16.7 / 33.3 / 6	0.0 / 33.3 / 6	0.0 / 50.0 / 6	0.0 / 50.0 / 6
i=6	wAOBF	0.0 / 20.0 / 5	20.0 / 20.0 / 5	0.0 / 20.0 / 5	0.0 / 20.0 / 5	0.0 / 20.0 / 5
	wR-AOBF	20.0 / 20.0 / 5	20.0 / 20.0 / 5	0.0 / 20.0 / 5	0.0 / 20.0 / 5	0.0 / 20.0 / 5
	wAOBB	0.0 / 40.0 / 5	0.0 / 40.0 / 5	0.0 / 40.0 / 5	0.0 / 40.0 / 5	0.0 / 40.0 / 5
i=8	wAOBF	0.0 / 25.0 / 4	0.0 / 25.0 / 4	25.0 / 25.0 / 4	25.0 / 25.0 / 4	25.0 / 25.0 / 4
	wR-AOBF	25.0 / 25.0 / 4	25.0 / 25.0 / 4	25.0 / 25.0 / 4	25.0 / 25.0 / 4	25.0 / 25.0 / 4
	wAOBB	25.0 / 25.0 / 4	25.0 / 25.0 / 4	25.0 / 25.0 / 4	25.0 / 25.0 / 4	25.0 / 25.0 / 4
i=10	wAOBF	100.0 / 0.0 / 1	0.0 / 50.0 / 2	0.0 / 33.3 / 3	0.0 / 33.3 / 3	0.0 / 33.3 / 3
	wR-AOBF	100.0 / 0.0 / 1	0.0 / 50.0 / 2	0.0 / 33.3 / 3	0.0 / 33.3 / 3	0.0 / 33.3 / 3
	wAOBB	100.0 / 0.0 / 1	0.0 / 100.0 / 2	0.0 / 33.3 / 3	0.0 / 33.3 / 3	0.0 / 33.3 / 3
i=14	wAOBF	0 / 0 / 0	0.0 / 100.0 / 1	0.0 / 100.0 / 1	0.0 / 100.0 / 1	0.0 / 100.0 / 1
	wR-AOBF	0 / 0 / 0	0.0 / 100.0 / 1	0.0 / 100.0 / 1	0.0 / 100.0 / 1	0.0 / 100.0 / 1
	wAOBB	0 / 0 / 0	0.0 / 100.0 / 1	0.0 / 100.0 / 1	0.0 / 100.0 / 1	0.0 / 100.0 / 1
i=18	wAOBF	0 / 0 / 0	0.0 / 100.0 / 1	0.0 / 100.0 / 1	0.0 / 100.0 / 1	0.0 / 100.0 / 1
	wR-AOBF	0 / 0 / 0	0.0 / 100.0 / 1	0.0 / 100.0 / 1	0.0 / 100.0 / 1	0.0 / 100.0 / 1
	wAOBB	0 / 0 / 0	0.0 / 100.0 / 1	0.0 / 100.0 / 1	0.0 / 100.0 / 1	0.0 / 100.0 / 1

I-bound	Algorithm	Time bounds				
		10	30	600	3600	21600
		X% / Y% / N	X% / Y% / N	X% / Y% / N	X% / Y% / N	X% / Y% / N
Type4 (# inst=10, $n = 3938 - 8186, k = 5, w^* = 24 - 32, h_T = 319 - 625$						
i=2	wAOBF	100.0 / 0.0 / 1	66.7 / 0.0 / 3	66.7 / 0.0 / 3	66.7 / 0.0 / 3	100.0 / 0.0 / 3
	wR-AOBF	0.0 / 0.0 / 1	33.3 / 0.0 / 3	33.3 / 0.0 / 3	66.7 / 0.0 / 3	66.7 / 0.0 / 3
	wAOBB	0.0 / 400.0 / 1	33.3 / 66.7 / 3	33.3 / 133.3 / 3	33.3 / 100.0 / 3	33.3 / 166.7 / 3
i=4	wAOBF	100.0 / 0.0 / 1	75.0 / 0.0 / 4	83.3 / 0.0 / 6	50.0 / 0.0 / 6	100.0 / 0.0 / 6
	wR-AOBF	0.0 / 0.0 / 1	25.0 / 0.0 / 4	33.3 / 0.0 / 6	50.0 / 0.0 / 6	50.0 / 0.0 / 6
	wAOBB	100.0 / 200.0 / 1	25.0 / 75.0 / 4	33.3 / 33.3 / 6	16.7 / 33.3 / 6	33.3 / 33.3 / 6
i=6	wAOBF	0.0 / 0.0 / 1	75.0 / 0.0 / 4	60.0 / 0.0 / 5	80.0 / 0.0 / 5	80.0 / 0.0 / 5
	wR-AOBF	0.0 / 0.0 / 1	0.0 / 0.0 / 4	0.0 / 0.0 / 5	0.0 / 0.0 / 5	20.0 / 0.0 / 5
	wAOBB	0.0 / 200.0 / 1	25.0 / 50.0 / 4	20.0 / 20.0 / 5	60.0 / 0.0 / 5	20.0 / 20.0 / 5
i=8	wAOBF	66.7 / 0.0 / 3	50.0 / 0.0 / 6	33.3 / 0.0 / 6	100.0 / 0.0 / 6	100.0 / 0.0 / 6
	wR-AOBF	33.3 / 0.0 / 3	33.3 / 0.0 / 6	66.7 / 0.0 / 6	66.7 / 0.0 / 6	66.7 / 0.0 / 6
	wAOBB	33.3 / 66.7 / 3	50.0 / 0.0 / 6	16.7 / 0.0 / 6	16.7 / 0.0 / 6	50.0 / 0.0 / 6
i=10	wAOBF	25.0 / 0.0 / 8	11.1 / 0.0 / 9	70.0 / 0.0 / 10	80.0 / 0.0 / 10	90.0 / 0.0 / 10
	wR-AOBF	12.5 / 0.0 / 8	33.3 / 0.0 / 9	20.0 / 0.0 / 10	20.0 / 0.0 / 10	20.0 / 0.0 / 10
	wAOBB	25.0 / 0.0 / 8	11.1 / 11.1 / 9	30.0 / 0.0 / 10	20.0 / 0.0 / 10	30.0 / 0.0 / 10
i=12	wAOBF	60.0 / 0.0 / 5	16.7 / 0.0 / 6	66.7 / 0.0 / 6	83.3 / 0.0 / 6	83.3 / 0.0 / 6
	wR-AOBF	20.0 / 0.0 / 5	16.7 / 0.0 / 6	16.7 / 0.0 / 6	16.7 / 0.0 / 6	16.7 / 0.0 / 6
	wAOBB	20.0 / 20.0 / 5	33.3 / 0.0 / 6	16.7 / 0.0 / 6	16.7 / 0.0 / 6	16.7 / 16.7 / 6
i=14	wAOBF	22.2 / 0.0 / 9	30.0 / 0.0 / 10	90.0 / 0.0 / 10	80.0 / 0.0 / 10	70.0 / 0.0 / 10
	wR-AOBF	0.0 / 0.0 / 9	0.0 / 0.0 / 10	0.0 / 0.0 / 10	0.0 / 0.0 / 10	0.0 / 0.0 / 10
	wAOBB	11.1 / 11.1 / 9	10.0 / 10.0 / 10	0.0 / 30.0 / 10	0.0 / 30.0 / 10	0.0 / 30.0 / 10
i=18	wAOBF	0.0 / 0.0 / 4	0.0 / 11.1 / 9	33.3 / 22.2 / 9	44.4 / 22.2 / 9	44.4 / 22.2 / 9
	wR-AOBF	0.0 / 25.0 / 4	0.0 / 22.2 / 9	0.0 / 22.2 / 9	0.0 / 22.2 / 9	0.0 / 22.2 / 9
	wAOBB	0.0 / 0.0 / 4	0.0 / 55.6 / 9	0.0 / 66.7 / 9	0.0 / 66.7 / 9	22.2 / 55.6 / 9
Grids (# inst=10, $n = 144 - 2500, k = 2, w^* = 15 - 74, h_T = 48 - 312$						
i=2	wAOBF	56.3 / 6.3 / 16	73.7 / 5.3 / 19	63.2 / 21.1 / 19	47.6 / 19.0 / 21	31.8 / 18.2 / 22
	wR-AOBF	43.8 / 6.3 / 16	42.1 / 5.3 / 19	31.6 / 21.1 / 19	4.8 / 19.0 / 21	9.1 / 18.2 / 22
	wAOBB	18.8 / 112.5 / 16	31.6 / 89.5 / 19	26.3 / 84.2 / 19	38.1 / 71.4 / 21	18.2 / 72.7 / 22
i=4	wAOBF	50.0 / 9.1 / 22	58.3 / 20.8 / 24	37.5 / 29.2 / 24	20.8 / 33.3 / 24	16.0 / 32.0 / 25
	wR-AOBF	27.3 / 9.1 / 22	33.3 / 16.7 / 24	25.0 / 29.2 / 24	8.3 / 29.2 / 24	4.0 / 28.0 / 25
	wAOBB	36.4 / 68.2 / 22	16.7 / 58.3 / 24	8.3 / 79.2 / 24	16.7 / 66.7 / 24	12.0 / 72.0 / 25
i=6	wAOBF	45.8 / 25.0 / 24	46.2 / 46.2 / 26	34.6 / 53.8 / 26	18.5 / 51.9 / 27	10.7 / 50.0 / 28
	wR-AOBF	29.2 / 29.2 / 24	23.1 / 46.2 / 26	23.1 / 53.8 / 26	14.8 / 51.9 / 27	7.1 / 50.0 / 28
	wAOBB	16.7 / 79.2 / 24	15.4 / 76.9 / 26	11.5 / 76.9 / 26	11.1 / 85.2 / 27	7.1 / 85.7 / 28
i=8	wAOBF	40.7 / 25.9 / 27	37.0 / 51.9 / 27	22.2 / 59.3 / 27	11.1 / 63.0 / 27	3.6 / 60.7 / 28
	wR-AOBF	33.3 / 40.7 / 27	25.9 / 51.9 / 27	3.7 / 59.3 / 27	3.7 / 59.3 / 27	3.6 / 57.1 / 28
	wAOBB	29.6 / 59.3 / 27	14.8 / 74.1 / 27	7.4 / 88.9 / 27	11.1 / 96.3 / 27	7.1 / 92.9 / 28
i=10	wAOBF	29.6 / 55.6 / 27	18.5 / 66.7 / 27	14.8 / 81.5 / 27	7.4 / 81.5 / 27	0.0 / 79.3 / 29
	wR-AOBF	18.5 / 59.3 / 27	7.4 / 74.1 / 27	3.7 / 81.5 / 27	0.0 / 81.5 / 27	0.0 / 75.9 / 29
	wAOBB	18.5 / 74.1 / 27	3.7 / 100.0 / 27	0.0 / 111.1 / 27	7.4 / 100.0 / 27	3.4 / 93.1 / 29
i=12	wAOBF	22.7 / 54.5 / 22	4.3 / 78.3 / 23	4.3 / 87.0 / 23	0.0 / 87.5 / 24	0.0 / 91.7 / 24
	wR-AOBF	13.6 / 68.2 / 22	0.0 / 82.6 / 23	0.0 / 87.0 / 23	0.0 / 79.2 / 24	0.0 / 79.2 / 24
	wAOBB	9.1 / 95.5 / 22	0.0 / 95.7 / 23	4.3 / 91.3 / 23	4.2 / 95.8 / 24	0.0 / 104.2 / 24
i=14	wAOBF	10.3 / 75.9 / 29	12.9 / 80.6 / 31	9.4 / 81.3 / 32	9.4 / 84.4 / 32	6.3 / 84.4 / 32
	wR-AOBF	3.4 / 82.8 / 29	6.5 / 80.6 / 31	0.0 / 78.1 / 32	0.0 / 78.1 / 32	0.0 / 78.1 / 32
	wAOBB	3.4 / 93.1 / 29	3.2 / 90.3 / 31	6.3 / 84.4 / 32	0.0 / 87.5 / 32	0.0 / 90.6 / 32
i=18	wAOBF	0.0 / 86.7 / 30	6.5 / 87.1 / 31	9.7 / 87.1 / 31	3.2 / 87.1 / 31	3.2 / 87.1 / 31
	wR-AOBF	10.0 / 90.0 / 30	3.2 / 87.1 / 31	3.2 / 87.1 / 31	0.0 / 87.1 / 31	0.0 / 87.1 / 31
	wAOBB	0.0 / 86.7 / 30	6.5 / 90.3 / 31	6.5 / 93.5 / 31	3.2 / 100.0 / 31	3.2 / 100.0 / 31

I-bound	Algorithm	Time bounds				
		10	30	600	3600	21600
		X% / Y% / N	X% / Y% / N	X% / Y% / N	X% / Y% / N	X% / Y% / N
Proteins (# inst=239, $n = 9 - 211, k = 81, w^* = 1 - 16, h_T = 2 - 55$						
i=2	wAOBF	6.7 / 67.8 / 239	6.7 / 82.8 / 239	5.0 / 86.6 / 239	2.9 / 87.9 / 239	1.7 / 88.7 / 239
	wR-AOBF	8.8 / 72.4 / 239	6.7 / 81.2 / 239	4.6 / 83.3 / 239	2.1 / 84.5 / 239	0.4 / 85.4 / 239
	wAOBB	12.1 / 82.4 / 239	8.4 / 87.4 / 239	6.7 / 91.6 / 239	4.2 / 94.1 / 239	2.5 / 97.1 / 239
i=4	wAOBF	1.5 / 77.8 / 135	0.7 / 94.7 / 152	0.0 / 96.7 / 152	0.0 / 96.7 / 152	0.0 / 96.7 / 152
	wR-AOBF	3.0 / 88.9 / 135	0.7 / 92.8 / 152	0.7 / 94.1 / 152	0.0 / 94.7 / 152	0.0 / 94.7 / 152
	wAOBB	4.4 / 94.8 / 135	0.7 / 98.7 / 152	0.7 / 99.3 / 152	0.0 / 100.0 / 152	0.0 / 100.0 / 152
i=6	wAOBF	0.0 / 100.0 / 29	0.0 / 100.0 / 30	0.0 / 100.0 / 30	0.0 / 100.0 / 30	0.0 / 100.0 / 30
	wR-AOBF	0.0 / 100.0 / 29	0.0 / 100.0 / 30	0.0 / 100.0 / 30	0.0 / 100.0 / 30	0.0 / 100.0 / 30
	wAOBB	0.0 / 100.0 / 29	0.0 / 100.0 / 30	0.0 / 100.0 / 30	0.0 / 100.0 / 30	0.0 / 100.0 / 30
i=8	wAOBF	0.0 / 100.0 / 26	0.0 / 100.0 / 26	0.0 / 100.0 / 26	0.0 / 100.0 / 26	0.0 / 100.0 / 26
	wR-AOBF	0.0 / 100.0 / 26	0.0 / 100.0 / 26	0.0 / 100.0 / 26	0.0 / 100.0 / 26	0.0 / 100.0 / 26
	wAOBB	0.0 / 100.0 / 26	0.0 / 100.0 / 26	0.0 / 100.0 / 26	0.0 / 100.0 / 26	0.0 / 100.0 / 26
i=10	wAOBF	0.0 / 100.0 / 26	0.0 / 100.0 / 26	0.0 / 100.0 / 26	0.0 / 100.0 / 26	0.0 / 100.0 / 26
	wR-AOBF	0.0 / 100.0 / 26	0.0 / 100.0 / 26	0.0 / 100.0 / 26	0.0 / 100.0 / 26	0.0 / 100.0 / 26
	wAOBB	0.0 / 100.0 / 26	0.0 / 100.0 / 26	0.0 / 100.0 / 26	0.0 / 100.0 / 26	0.0 / 100.0 / 26
i=12	wAOBF	0.0 / 100.0 / 11	0.0 / 100.0 / 11	0.0 / 100.0 / 11	0.0 / 100.0 / 11	0.0 / 100.0 / 11
	wR-AOBF	0.0 / 100.0 / 11	0.0 / 100.0 / 11	0.0 / 100.0 / 11	0.0 / 100.0 / 11	0.0 / 100.0 / 11
	wAOBB	0.0 / 100.0 / 11	0.0 / 100.0 / 11	0.0 / 100.0 / 11	0.0 / 100.0 / 11	0.0 / 100.0 / 11
i=14	wAOBF	0.0 / 100.0 / 26	0.0 / 100.0 / 26	0.0 / 100.0 / 26	0.0 / 100.0 / 26	0.0 / 100.0 / 26
	wR-AOBF	0.0 / 100.0 / 26	0.0 / 100.0 / 26	0.0 / 100.0 / 26	0.0 / 100.0 / 26	0.0 / 100.0 / 26
	wAOBB	0.0 / 100.0 / 26	0.0 / 100.0 / 26	0.0 / 100.0 / 26	0.0 / 100.0 / 26	0.0 / 100.0 / 26
i=18	wAOBF	0.0 / 100.0 / 26	0.0 / 100.0 / 26	0.0 / 100.0 / 26	0.0 / 100.0 / 26	0.0 / 100.0 / 26
	wR-AOBF	0.0 / 100.0 / 26	0.0 / 100.0 / 26	0.0 / 100.0 / 26	0.0 / 100.0 / 26	0.0 / 100.0 / 26
	wAOBB	0.0 / 100.0 / 26	0.0 / 100.0 / 26	0.0 / 100.0 / 26	0.0 / 100.0 / 26	0.0 / 100.0 / 26
Image Alignment (# inst=10, $n = 30 - 400, k = 47 - 93, w^* = 17 - 30, h_T = 29 - 134$						
i=2	wAOBF	0.0 / 44.4 / 9	0.0 / 50.0 / 10	0.0 / 80.0 / 10	0.0 / 90.0 / 10	0.0 / 90.0 / 10
	wR-AOBF	0.0 / 66.7 / 9	0.0 / 60.0 / 10	0.0 / 70.0 / 10	0.0 / 70.0 / 10	0.0 / 70.0 / 10
	wAOBB	0.0 / 88.9 / 9	0.0 / 100.0 / 10	0.0 / 100.0 / 10	0.0 / 100.0 / 10	0.0 / 100.0 / 10
i=4	wAOBF	0 / 0 / 0	0.0 / 100.0 / 1	0.0 / 100.0 / 2	0.0 / 100.0 / 2	0.0 / 100.0 / 2
	wR-AOBF	0 / 0 / 0	0.0 / 100.0 / 1	0.0 / 100.0 / 2	0.0 / 100.0 / 2	0.0 / 100.0 / 2
	wAOBB	0 / 0 / 0	0.0 / 100.0 / 1	0.0 / 100.0 / 2	0.0 / 100.0 / 2	0.0 / 100.0 / 2
i=6	wAOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wR-AOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wAOBB	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
i=8	wAOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wR-AOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wAOBB	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
i=10	wAOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wR-AOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wAOBB	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
i=14	wAOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wR-AOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wAOBB	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
i=18	wAOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wR-AOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wAOBB	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0

I-bound	Algorithm	Time bounds				
		10	30	600	3600	21600
		X% / Y% / N	X% / Y% / N	X% / Y% / N	X% / Y% / N	X% / Y% / N
Object Detection (# inst=37, $n = 60, k = 11 - 21, w^* = 59, h_T = 59$						
i=2	wAOBF	0.0 / 0.0 / 37	13.5 / 21.6 / 37	24.3 / 37.8 / 37	21.6 / 37.8 / 37	21.6 / 37.8 / 37
	wR-AOBF	2.7 / 2.7 / 37	5.4 / 2.7 / 37	5.4 / 2.7 / 37	2.7 / 5.4 / 37	2.7 / 5.4 / 37
	wAOBB	21.6 / 75.7 / 37	16.2 / 81.1 / 37	16.2 / 81.1 / 37	13.5 / 83.8 / 37	16.2 / 81.1 / 37
i=6	wAOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wR-AOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wAOBB	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
i=10	wAOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wR-AOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wAOBB	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
i=14	wAOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wR-AOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wAOBB	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
i=18	wAOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wR-AOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wAOBB	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
Segmentation (# inst=48, $n = 221 - 233, k = 2, w^* = 15 - 17, h_T = 49 - 67$						
i=2	wAOBF	4.3 / 0.0 / 46	23.9 / 34.8 / 46	23.9 / 37.0 / 46	19.6 / 37.0 / 46	17.4 / 37.0 / 46
	wR-AOBF	10.9 / 6.5 / 46	15.2 / 17.4 / 46	15.2 / 26.1 / 46	15.2 / 26.1 / 46	13.0 / 26.1 / 46
	wAOBB	23.9 / 69.6 / 46	17.4 / 80.4 / 46	17.4 / 78.3 / 46	23.9 / 76.1 / 46	19.6 / 78.3 / 46
i=4	wAOBF	0.0 / 0.0 / 1	10.6 / 42.6 / 47	10.6 / 40.4 / 47	2.1 / 42.6 / 47	0.0 / 44.7 / 47
	wR-AOBF	0.0 / 0.0 / 1	12.8 / 36.2 / 47	10.6 / 38.3 / 47	2.1 / 40.4 / 47	0.0 / 42.6 / 47
	wAOBB	0.0 / 0.0 / 1	4.3 / 93.6 / 47	6.4 / 91.5 / 47	2.1 / 95.7 / 47	0.0 / 97.9 / 47
i=6	wAOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wR-AOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wAOBB	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
i=8	wAOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wR-AOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wAOBB	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
i=10	wAOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wR-AOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wAOBB	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
i=12	wAOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wR-AOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wAOBB	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
i=14	wAOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wR-AOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wAOBB	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
i=18	wAOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wR-AOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wAOBB	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0

Table 3: X% - percentage of instances for which each algorithm is the better than BRAOBB at a specific time bound, Y% - percentage of instances for which algorithm ties with BRAOBB, N - number of instances for which at least one of algorithms found a solution. # inst - total number of instances in benchmark, n - number of variables, k - maximum domain size, w^* -induced width, h_T - pseudo-tree height.

2.5.2 JGLP heuristic

I-bound	Algorithm	Time bounds				
		10	30	600	3600	21600
		X% / Y% / N	X% / Y% / N	X% / Y% / N	X% / Y% / N	X% / Y% / N
Pedigrees (# inst=16, $n = 298 - 1015, k = 3 - 7, w^* = 15 - 33, h_T = 59 - 140$						
i=2	wAOBF	0 / 0 / 0	43.8 / 6.3 / 16	31.3 / 25.0 / 16	37.5 / 25.0 / 16	25.0 / 25.0 / 16
	wR-AOBF	0 / 0 / 0	31.3 / 18.8 / 16	25.0 / 31.3 / 16	25.0 / 31.3 / 16	12.5 / 31.3 / 16
	wAOBB	0 / 0 / 0	56.3 / 31.3 / 16	12.5 / 62.5 / 16	18.8 / 75.0 / 16	25.0 / 68.8 / 16
i=4	wAOBF	0 / 0 / 0	31.3 / 18.8 / 16	12.5 / 37.5 / 16	25.0 / 37.5 / 16	6.3 / 37.5 / 16
	wR-AOBF	0 / 0 / 0	37.5 / 25.0 / 16	12.5 / 37.5 / 16	12.5 / 37.5 / 16	0.0 / 37.5 / 16
	wAOBB	0 / 0 / 0	18.8 / 62.5 / 16	25.0 / 62.5 / 16	25.0 / 75.0 / 16	6.3 / 93.8 / 16
i=6	wAOBF	0 / 0 / 0	6.3 / 50.0 / 16	12.5 / 56.3 / 16	0.0 / 56.3 / 16	0.0 / 56.3 / 16
	wR-AOBF	0 / 0 / 0	6.3 / 43.8 / 16	6.3 / 50.0 / 16	0.0 / 50.0 / 16	0.0 / 50.0 / 16
	wAOBB	0 / 0 / 0	12.5 / 68.8 / 16	12.5 / 87.5 / 16	6.3 / 93.8 / 16	0.0 / 100.0 / 16
i=8	wAOBF	0 / 0 / 0	0.0 / 46.7 / 15	6.3 / 50.0 / 16	0.0 / 50.0 / 16	0.0 / 50.0 / 16
	wR-AOBF	0 / 0 / 0	6.7 / 53.3 / 15	6.3 / 50.0 / 16	0.0 / 50.0 / 16	0.0 / 50.0 / 16
	wAOBB	0 / 0 / 0	6.7 / 80.0 / 15	6.3 / 87.5 / 16	0.0 / 87.5 / 16	0.0 / 87.5 / 16
i=10	wAOBF	0 / 0 / 0	6.3 / 50.0 / 16	0.0 / 62.5 / 16	0.0 / 62.5 / 16	0.0 / 62.5 / 16
	wR-AOBF	0 / 0 / 0	0.0 / 56.3 / 16	0.0 / 62.5 / 16	0.0 / 62.5 / 16	0.0 / 62.5 / 16
	wAOBB	0 / 0 / 0	0.0 / 81.3 / 16	0.0 / 81.3 / 16	0.0 / 87.5 / 16	0.0 / 100.0 / 16
i=12	wAOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wR-AOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wAOBB	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
i=14	wAOBF	0 / 0 / 0	7.1 / 57.1 / 14	0.0 / 57.1 / 14	0.0 / 57.1 / 14	0.0 / 57.1 / 14
	wR-AOBF	0 / 0 / 0	0.0 / 57.1 / 14	0.0 / 57.1 / 14	0.0 / 57.1 / 14	0.0 / 57.1 / 14
	wAOBB	0 / 0 / 0	0.0 / 92.9 / 14	0.0 / 92.9 / 14	0.0 / 92.9 / 14	0.0 / 100.0 / 14
i=18	wAOBF	0 / 0 / 0	0.0 / 75.0 / 8	0.0 / 77.8 / 9	0.0 / 77.8 / 9	0.0 / 77.8 / 9
	wR-AOBF	0 / 0 / 0	0.0 / 75.0 / 8	0.0 / 77.8 / 9	0.0 / 77.8 / 9	0.0 / 77.8 / 9
	wAOBB	0 / 0 / 0	0.0 / 100.0 / 8	0.0 / 100.0 / 9	0.0 / 100.0 / 9	0.0 / 100.0 / 9
WCSPs (# inst=8, $n = 100 - 665, k = 2 - 3, w^* = 19 - 89, h_T = 45 - 287$						
i=2	wAOBF	0 / 0 / 0	25.0 / 37.5 / 8	25.0 / 37.5 / 8	25.0 / 37.5 / 8	25.0 / 37.5 / 8
	wR-AOBF	0 / 0 / 0	25.0 / 37.5 / 8	25.0 / 37.5 / 8	25.0 / 37.5 / 8	25.0 / 37.5 / 8
	wAOBB	0 / 0 / 0	25.0 / 50.0 / 8	25.0 / 50.0 / 8	25.0 / 50.0 / 8	37.5 / 50.0 / 8
i=4	wAOBF	0 / 0 / 0	33.3 / 33.3 / 6	33.3 / 33.3 / 6	33.3 / 33.3 / 6	33.3 / 33.3 / 6
	wR-AOBF	0 / 0 / 0	33.3 / 33.3 / 6	33.3 / 33.3 / 6	33.3 / 33.3 / 6	33.3 / 33.3 / 6
	wAOBB	0 / 0 / 0	33.3 / 33.3 / 6	33.3 / 50.0 / 6	33.3 / 50.0 / 6	33.3 / 50.0 / 6
i=6	wAOBF	0 / 0 / 0	25.0 / 25.0 / 4	50.0 / 50.0 / 4	50.0 / 50.0 / 4	25.0 / 50.0 / 4
	wR-AOBF	0 / 0 / 0	50.0 / 25.0 / 4	25.0 / 25.0 / 4	25.0 / 25.0 / 4	0.0 / 25.0 / 4
	wAOBB	0 / 0 / 0	50.0 / 25.0 / 4	25.0 / 50.0 / 4	25.0 / 50.0 / 4	0.0 / 50.0 / 4
i=8	wAOBF	0 / 0 / 0	66.7 / 33.3 / 3	66.7 / 33.3 / 3	66.7 / 33.3 / 3	66.7 / 33.3 / 3
	wR-AOBF	0 / 0 / 0	33.3 / 33.3 / 3	33.3 / 33.3 / 3	66.7 / 33.3 / 3	66.7 / 33.3 / 3
	wAOBB	0 / 0 / 0	33.3 / 33.3 / 3	33.3 / 33.3 / 3	66.7 / 33.3 / 3	66.7 / 33.3 / 3
i=10	wAOBF	0 / 0 / 0	0.0 / 100.0 / 1	0.0 / 100.0 / 1	0.0 / 100.0 / 1	0.0 / 100.0 / 1
	wR-AOBF	0 / 0 / 0	0.0 / 100.0 / 1	0.0 / 100.0 / 1	0.0 / 100.0 / 1	0.0 / 100.0 / 1
	wAOBB	0 / 0 / 0	0.0 / 100.0 / 1	0.0 / 100.0 / 1	0.0 / 100.0 / 1	0.0 / 100.0 / 1
i=14	wAOBF	0 / 0 / 0	0.0 / 100.0 / 1	0.0 / 100.0 / 1	0.0 / 100.0 / 1	0.0 / 100.0 / 1
	wR-AOBF	0 / 0 / 0	0.0 / 100.0 / 1	0.0 / 100.0 / 1	0.0 / 100.0 / 1	0.0 / 100.0 / 1
	wAOBB	0 / 0 / 0	0.0 / 100.0 / 1	0.0 / 100.0 / 1	0.0 / 100.0 / 1	0.0 / 100.0 / 1
i=18	wAOBF	0 / 0 / 0	0.0 / 100.0 / 1	0.0 / 100.0 / 1	0.0 / 100.0 / 1	0.0 / 100.0 / 1
	wR-AOBF	0 / 0 / 0	0.0 / 100.0 / 1	0.0 / 100.0 / 1	0.0 / 100.0 / 1	0.0 / 100.0 / 1
	wAOBB	0 / 0 / 0	0.0 / 100.0 / 1	0.0 / 100.0 / 1	0.0 / 100.0 / 1	0.0 / 100.0 / 1

I-bound	Algorithm	Time bounds				
		10	30	600	3600	21600
		X% / Y% / N	X% / Y% / N	X% / Y% / N	X% / Y% / N	X% / Y% / N
Type4 (# inst=10, $n = 3938 - 8186, k = 5, w^* = 24 - 32, h_T = 319 - 625$						
i=2	wAOBF	0 / 0 / 0	66.7 / 0.0 / 3	33.3 / 0.0 / 3	66.7 / 0.0 / 3	66.7 / 0.0 / 3
	wR-AOBF	0 / 0 / 0	33.3 / 0.0 / 3	66.7 / 0.0 / 3	100.0 / 0.0 / 3	100.0 / 0.0 / 3
	wAOBB	0 / 0 / 0	33.3 / 100.0 / 3	33.3 / 133.3 / 3	33.3 / 166.7 / 3	33.3 / 166.7 / 3
i=4	wAOBF	0 / 0 / 0	50.0 / 0.0 / 2	75.0 / 0.0 / 4	80.0 / 0.0 / 5	60.0 / 0.0 / 5
	wR-AOBF	0 / 0 / 0	50.0 / 0.0 / 2	25.0 / 0.0 / 4	20.0 / 0.0 / 5	20.0 / 0.0 / 5
	wAOBB	0 / 0 / 0	0.0 / 100.0 / 2	50.0 / 50.0 / 4	80.0 / 20.0 / 5	60.0 / 0.0 / 5
i=6	wAOBF	0 / 0 / 0	50.0 / 0.0 / 4	50.0 / 0.0 / 6	83.3 / 0.0 / 6	66.7 / 0.0 / 6
	wR-AOBF	0 / 0 / 0	25.0 / 0.0 / 4	50.0 / 0.0 / 6	50.0 / 0.0 / 6	50.0 / 0.0 / 6
	wAOBB	0 / 0 / 0	50.0 / 25.0 / 4	33.3 / 16.7 / 6	66.7 / 33.3 / 6	50.0 / 33.3 / 6
i=8	wAOBF	0 / 0 / 0	60.0 / 0.0 / 5	50.0 / 0.0 / 6	66.7 / 0.0 / 6	83.3 / 0.0 / 6
	wR-AOBF	0 / 0 / 0	0.0 / 0.0 / 5	16.7 / 0.0 / 6	16.7 / 0.0 / 6	16.7 / 0.0 / 6
	wAOBB	0 / 0 / 0	40.0 / 40.0 / 5	33.3 / 0.0 / 6	0.0 / 0.0 / 6	0.0 / 0.0 / 6
i=10	wAOBF	0 / 0 / 0	33.3 / 0.0 / 9	50.0 / 0.0 / 10	60.0 / 0.0 / 10	70.0 / 0.0 / 10
	wR-AOBF	0 / 0 / 0	0.0 / 0.0 / 9	10.0 / 0.0 / 10	10.0 / 0.0 / 10	10.0 / 0.0 / 10
	wAOBB	0 / 0 / 0	33.3 / 0.0 / 9	10.0 / 0.0 / 10	0.0 / 0.0 / 10	10.0 / 10.0 / 10
i=12	wAOBF	0 / 0 / 0	16.7 / 0.0 / 6	66.7 / 0.0 / 6	83.3 / 0.0 / 6	83.3 / 0.0 / 6
	wR-AOBF	0 / 0 / 0	33.3 / 0.0 / 6	33.3 / 0.0 / 6	33.3 / 0.0 / 6	33.3 / 0.0 / 6
	wAOBB	0 / 0 / 0	0.0 / 0.0 / 6	16.7 / 16.7 / 6	16.7 / 16.7 / 6	16.7 / 16.7 / 6
i=14	wAOBF	0 / 0 / 0	0.0 / 0.0 / 8	66.7 / 0.0 / 9	66.7 / 0.0 / 9	66.7 / 0.0 / 9
	wR-AOBF	0 / 0 / 0	0.0 / 0.0 / 8	0.0 / 0.0 / 9	0.0 / 0.0 / 9	0.0 / 0.0 / 9
	wAOBB	0 / 0 / 0	0.0 / 0.0 / 8	0.0 / 33.3 / 9	11.1 / 33.3 / 9	11.1 / 33.3 / 9
i=18	wAOBF	0 / 0 / 0	0 / 0 / 0	0.0 / 100.0 / 1	0.0 / 100.0 / 1	0.0 / 100.0 / 1
	wR-AOBF	0 / 0 / 0	0 / 0 / 0	0.0 / 100.0 / 1	0.0 / 100.0 / 1	0.0 / 100.0 / 1
	wAOBB	0 / 0 / 0	0 / 0 / 0	0.0 / 100.0 / 1	0.0 / 100.0 / 1	0.0 / 100.0 / 1
Grids (# inst=10, $n = 144 - 2500, k = 2, w^* = 15 - 74, h_T = 48 - 312$						
i=2	wAOBF	0 / 0 / 0	57.1 / 23.8 / 21	59.1 / 31.8 / 22	30.4 / 30.4 / 23	16.7 / 33.3 / 24
	wR-AOBF	0 / 0 / 0	38.1 / 19.0 / 21	31.8 / 22.7 / 22	13.0 / 26.1 / 23	8.3 / 25.0 / 24
	wAOBB	0 / 0 / 0	19.0 / 76.2 / 21	31.8 / 77.3 / 22	39.1 / 73.9 / 23	25.0 / 70.8 / 24
i=4	wAOBF	0 / 0 / 0	18.5 / 40.7 / 27	13.8 / 48.3 / 29	13.8 / 58.6 / 29	6.9 / 62.1 / 29
	wR-AOBF	0 / 0 / 0	25.9 / 37.0 / 27	17.2 / 48.3 / 29	6.9 / 55.2 / 29	6.9 / 55.2 / 29
	wAOBB	0 / 0 / 0	11.1 / 63.0 / 27	10.3 / 65.5 / 29	13.8 / 72.4 / 29	3.4 / 89.7 / 29
i=6	wAOBF	0 / 0 / 0	3.2 / 77.4 / 31	0.0 / 87.1 / 31	0.0 / 90.3 / 31	0.0 / 90.3 / 31
	wR-AOBF	0 / 0 / 0	6.5 / 87.1 / 31	3.2 / 87.1 / 31	0.0 / 90.3 / 31	0.0 / 90.3 / 31
	wAOBB	0 / 0 / 0	3.2 / 80.6 / 31	0.0 / 96.8 / 31	0.0 / 100.0 / 31	0.0 / 103.2 / 31
i=8	wAOBF	0 / 0 / 0	6.5 / 90.3 / 31	3.2 / 90.3 / 31	3.2 / 93.5 / 31	0.0 / 93.5 / 31
	wR-AOBF	0 / 0 / 0	3.2 / 90.3 / 31	3.2 / 93.5 / 31	3.2 / 93.5 / 31	0.0 / 93.5 / 31
	wAOBB	0 / 0 / 0	0.0 / 93.5 / 31	0.0 / 100.0 / 31	6.5 / 93.5 / 31	0.0 / 103.2 / 31
i=10	wAOBF	0 / 0 / 0	3.2 / 93.5 / 31	0.0 / 96.8 / 31	0.0 / 96.8 / 31	0.0 / 96.8 / 31
	wR-AOBF	0 / 0 / 0	0.0 / 96.8 / 31	0.0 / 96.8 / 31	0.0 / 96.8 / 31	0.0 / 96.8 / 31
	wAOBB	0 / 0 / 0	3.2 / 100.0 / 31	0.0 / 100.0 / 31	0.0 / 100.0 / 31	0.0 / 103.2 / 31
i=12	wAOBF	0 / 0 / 0	11.1 / 81.5 / 27	3.7 / 85.2 / 27	0.0 / 88.9 / 27	0.0 / 88.9 / 27
	wR-AOBF	0 / 0 / 0	7.4 / 85.2 / 27	3.7 / 88.9 / 27	0.0 / 88.9 / 27	0.0 / 88.9 / 27
	wAOBB	0 / 0 / 0	3.7 / 88.9 / 27	7.4 / 85.2 / 27	3.7 / 92.6 / 27	3.7 / 96.3 / 27
i=14	wAOBF	0 / 0 / 0	3.1 / 84.4 / 32	3.1 / 87.5 / 32	3.1 / 90.6 / 32	3.1 / 90.6 / 32
	wR-AOBF	0 / 0 / 0	9.4 / 87.5 / 32	3.1 / 90.6 / 32	3.1 / 90.6 / 32	3.1 / 90.6 / 32
	wAOBB	0 / 0 / 0	0.0 / 87.5 / 32	3.1 / 90.6 / 32	3.1 / 96.9 / 32	3.1 / 96.9 / 32
i=18	wAOBF	0 / 0 / 0	0.0 / 89.3 / 28	0.0 / 90.0 / 30	3.3 / 93.3 / 30	0.0 / 93.3 / 30
	wR-AOBF	0 / 0 / 0	3.6 / 96.4 / 28	6.7 / 93.3 / 30	3.3 / 93.3 / 30	0.0 / 93.3 / 30
	wAOBB	0 / 0 / 0	3.6 / 92.9 / 28	0.0 / 86.7 / 30	0.0 / 93.3 / 30	0.0 / 100.0 / 30

I-bound	Algorithm	Time bounds				
		10	30	600	3600	21600
		X% / Y% / N	X% / Y% / N	X% / Y% / N	X% / Y% / N	X% / Y% / N
Proteins (# inst=239, $n = 9 - 211, k = 81, w^* = 1 - 16, h_T = 2 - 55$						
i=2	wAOBF	0 / 0 / 0	0.0 / 100.0 / 239	0.0 / 100.0 / 239	0.0 / 100.0 / 239	0.0 / 100.0 / 239
	wR-AOBF	0 / 0 / 0	0.0 / 100.0 / 239	0.0 / 100.0 / 239	0.0 / 100.0 / 239	0.0 / 100.0 / 239
	wAOBB	0 / 0 / 0	0.0 / 100.0 / 239	0.0 / 100.0 / 239	0.0 / 100.0 / 239	0.0 / 100.0 / 239
i=4	wAOBF	0 / 0 / 0	0.0 / 100.0 / 52	0.0 / 100.0 / 52	0.0 / 100.0 / 52	0.0 / 100.0 / 52
	wR-AOBF	0 / 0 / 0	0.0 / 100.0 / 52	0.0 / 100.0 / 52	0.0 / 100.0 / 52	0.0 / 100.0 / 52
	wAOBB	0 / 0 / 0	0.0 / 100.0 / 52	0.0 / 100.0 / 52	0.0 / 100.0 / 52	0.0 / 100.0 / 52
i=6	wAOBF	0 / 0 / 0	0.0 / 100.0 / 23	0.0 / 100.0 / 23	0.0 / 100.0 / 23	0.0 / 100.0 / 23
	wR-AOBF	0 / 0 / 0	0.0 / 100.0 / 23	0.0 / 100.0 / 23	0.0 / 100.0 / 23	0.0 / 100.0 / 23
	wAOBB	0 / 0 / 0	0.0 / 100.0 / 23	0.0 / 100.0 / 23	0.0 / 100.0 / 23	0.0 / 100.0 / 23
i=8	wAOBF	0 / 0 / 0	0.0 / 100.0 / 21	0.0 / 100.0 / 21	0.0 / 100.0 / 21	0.0 / 100.0 / 21
	wR-AOBF	0 / 0 / 0	0.0 / 100.0 / 21	0.0 / 100.0 / 21	0.0 / 100.0 / 21	0.0 / 100.0 / 21
	wAOBB	0 / 0 / 0	0.0 / 100.0 / 21	0.0 / 100.0 / 21	0.0 / 100.0 / 21	0.0 / 100.0 / 21
i=10	wAOBF	0 / 0 / 0	0.0 / 100.0 / 21	0.0 / 100.0 / 21	0.0 / 100.0 / 21	0.0 / 100.0 / 21
	wR-AOBF	0 / 0 / 0	0.0 / 100.0 / 21	0.0 / 100.0 / 21	0.0 / 100.0 / 21	0.0 / 100.0 / 21
	wAOBB	0 / 0 / 0	0.0 / 100.0 / 21	0.0 / 100.0 / 21	0.0 / 100.0 / 21	0.0 / 100.0 / 21
i=12	wAOBF	0 / 0 / 0	0.0 / 100.0 / 7	0.0 / 100.0 / 7	0.0 / 100.0 / 7	0.0 / 100.0 / 7
	wR-AOBF	0 / 0 / 0	0.0 / 100.0 / 7	0.0 / 100.0 / 7	0.0 / 100.0 / 7	0.0 / 100.0 / 7
	wAOBB	0 / 0 / 0	0.0 / 100.0 / 7	0.0 / 100.0 / 7	0.0 / 100.0 / 7	0.0 / 100.0 / 7
i=14	wAOBF	0 / 0 / 0	0.0 / 100.0 / 21	0.0 / 100.0 / 21	0.0 / 100.0 / 21	0.0 / 100.0 / 21
	wR-AOBF	0 / 0 / 0	0.0 / 100.0 / 21	0.0 / 100.0 / 21	0.0 / 100.0 / 21	0.0 / 100.0 / 21
	wAOBB	0 / 0 / 0	0.0 / 100.0 / 21	0.0 / 100.0 / 21	0.0 / 100.0 / 21	0.0 / 100.0 / 21
i=18	wAOBF	0 / 0 / 0	0.0 / 100.0 / 21	0.0 / 100.0 / 21	0.0 / 100.0 / 21	0.0 / 100.0 / 21
	wR-AOBF	0 / 0 / 0	0.0 / 100.0 / 21	0.0 / 100.0 / 21	0.0 / 100.0 / 21	0.0 / 100.0 / 21
	wAOBB	0 / 0 / 0	0.0 / 100.0 / 21	0.0 / 100.0 / 21	0.0 / 100.0 / 21	0.0 / 100.0 / 21
Image Alignment (# inst=10, $n = 30 - 400, k = 47 - 93, w^* = 17 - 30, h_T = 29 - 134$						
i=2	wAOBF	0 / 0 / 0	0.0 / 85.7 / 7	0.0 / 100.0 / 7	0.0 / 100.0 / 7	0.0 / 100.0 / 7
	wR-AOBF	0 / 0 / 0	0.0 / 100.0 / 7	0.0 / 100.0 / 7	0.0 / 100.0 / 7	0.0 / 100.0 / 7
	wAOBB	0 / 0 / 0	0.0 / 100.0 / 7	0.0 / 100.0 / 7	0.0 / 100.0 / 7	0.0 / 100.0 / 7
i=4	wAOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wR-AOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wAOBB	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
i=6	wAOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wR-AOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wAOBB	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
i=8	wAOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wR-AOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wAOBB	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
i=10	wAOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wR-AOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wAOBB	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
i=12	wAOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wR-AOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wAOBB	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
i=14	wAOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wR-AOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wAOBB	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
i=18	wAOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wR-AOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wAOBB	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0

I-bound	Algorithm	Time bounds				
		10	30	600	3600	21600
		X% / Y% / N	X% / Y% / N	X% / Y% / N	X% / Y% / N	X% / Y% / N
Object Detection (# inst=37, $n = 60, k = 11 - 21, w^* = 59, h_T = 59$						
i=2	wAOBF	0 / 0 / 0	8.6 / 45.7 / 35	8.6 / 71.4 / 35	8.6 / 71.4 / 35	5.7 / 71.4 / 35
	wR-AOBF	0 / 0 / 0	8.6 / 40.0 / 35	8.6 / 40.0 / 35	8.6 / 40.0 / 35	5.7 / 40.0 / 35
	wAOBB	0 / 0 / 0	5.7 / 97.1 / 35	0.0 / 105.7 / 35	0.0 / 105.7 / 35	0.0 / 105.7 / 35
i=4	wAOBF	0 / 0 / 0	25.0 / 62.5 / 8	25.0 / 62.5 / 8	12.5 / 75.0 / 8	12.5 / 75.0 / 8
	wR-AOBF	0 / 0 / 0	12.5 / 12.5 / 8	12.5 / 12.5 / 8	0.0 / 12.5 / 8	0.0 / 12.5 / 8
	wAOBB	0 / 0 / 0	0.0 / 112.5 / 8	0.0 / 112.5 / 8	0.0 / 112.5 / 8	0.0 / 112.5 / 8
i=6	wAOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wR-AOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wAOBB	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
i=8	wAOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wR-AOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wAOBB	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
i=10	wAOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wR-AOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wAOBB	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
i=14	wAOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wR-AOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wAOBB	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
i=18	wAOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wR-AOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wAOBB	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
Segmentation (# inst=48, $n = 221 - 233, k = 2, w^* = 15 - 17, h_T = 49 - 67$						
i=2	wAOBF	0 / 0 / 0	0.0 / 100.0 / 46	0.0 / 100.0 / 46	0.0 / 100.0 / 46	0.0 / 100.0 / 46
	wR-AOBF	0 / 0 / 0	0.0 / 100.0 / 46	0.0 / 100.0 / 46	0.0 / 100.0 / 46	0.0 / 100.0 / 46
	wAOBB	0 / 0 / 0	0.0 / 100.0 / 46	0.0 / 100.0 / 46	0.0 / 100.0 / 46	0.0 / 100.0 / 46
i=4	wAOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wR-AOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wAOBB	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
i=6	wAOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wR-AOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wAOBB	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
i=8	wAOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wR-AOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wAOBB	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
i=10	wAOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wR-AOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wAOBB	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
i=14	wAOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wR-AOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wAOBB	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
i=18	wAOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wR-AOBF	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
	wAOBB	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0

Table 4: X% - percentage of instances for which each algorithm is the better than BRAOBB at a specific time bound, Y% - percentage of instances for which algorithm ties with BRAOBB, N - number of instances for which at least one of algorithms found a solution. # inst - total number of instances in benchmark, n - number of variables, k - maximum domain size, w^* -induced width, h_T - pseudo-tree height.

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