NuWLS: Improving Local Search for (Weighted) Partial MaxSAT by New Weighting Techniques (Technical Appendix)

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To evaluate the effect of different parameter settings on the performance of our NuWLS algorithm, we conducted the following experiments.

Experimental Methodology We evaluate NuWLS with different parameter settings on all benchmarks, and the related experimental results are obtained.

Experimental Setup NuWLS has 7 parameters, which are described detailedly in Section 5.1 of our submission. For s_{avg}, its setting is obtained from our empirical study described in Section 3.1. In particular, we set s_{avg} to 1000 and 3000 for PMS benchmarks and WPMS benchmarks, respectively.

For h_inc and s_inc, in the literature describing SATLike3.0 (Cai and Lei 2020), their values are both set to 1 for solving PMS instances, so NuWLS adopts the same parameter settings when solving PMS instances. For solving WPMS instances, the literature (Cai and Lei 2020) recommends that the ratio between h_inc and s_inc should be 3; follwing this recommendation, when solving WPMS instances, h_inc and s_inc are set to 30 and 10, respectively.

As described in Section 5.1, we used an algorithm configurator called SMAC (Hutter, Hoos, and Leyton-Brown 2011) to automatically configure the remaining 4 parameters of NuWLS, and we use P0 to denote the parameter settings obtained by SMAC. Then, on all benchmarks, NuWLS is evaluated with different parameter settings, which are around P0 with a certain range. The parameter settings and the detailed experimental results on PMS benchmarks and WPMS benchmarks are demonstrated in Tables 5 and Table 6, respectively.

Experimental Results Table 5 shows the winning instances (#win.) of NuWLS on solving `PMS_2019`, `PMS_2020`, and `PMS_2021` benchmarks under various parameter settings.

Table 6 shows the winning instances (#win.) of NuWLS on solving `WPMS_2019`, `WPMS_2020`, and `WPMS_2021` benchmarks under various parameter settings.

The experimental results show that NuWLS exhibits robustness across all benchmarks under various parameter settings.

Automatic Configurations for Competitors and Alternative Versions In order to make our comparisons fair, two SLS competitors (*i.e.,* SATLike3.0 and BandMaxSAT) and two alternative versions of NuWLS (*i.e.,* NuWLS-alt1 and NuWLS-alt2) were automatically configured using SMAC with the same configuration protocol.[1]

The parameter settings of SATLike, BandMaxSAT, NuWLS-alt1 and NuWLS-alt2 recommended by SMAC are described as below. Also, for each of SATLike, BandMaxSAT, NuWLS-alt1 and NuWLS-alt2, we conduct experiments to compare the related solver before and after parameter tuning.

SATLike:

h_inc: the increment for each falsified hard clause each time (This parameter does not participate in parameter tuning, as does NuWLS),

sp: the smooth probability of clause weights,

δ: whose value is the maximum weight of each soft clause,

t: the number of samples, used in BMS strategy.

h_inc is set according to SATLike3.0. We used SMAC to automatically configure the remaining 3 parameters of SATLike3.0.

For PMS benchmarks:

Default parameter settings: $t = 15$, sp=0.01, h_inc=1, δ=1, iff the number of variables <1100; otherwise $t = 42$, sp=3e-6, h_inc=1, δ=400 (Refer to SATLike3.0).

Configured parameter settings: $t = 15$, sp=0.01, h_inc=1, δ=1, iff the number of variables <1100; otherwise $t = 58$, sp=3e-4, h_inc=1, δ=386.

For WPMS benchmarks:

No better parameters were found using SMAC than those recommended in SATLike3.0. $t = 15$, sp=1e-7, h_inc=3, δ=1, iff soft clause average weight <10,000; otherwise $t = 15$, sp=1e-7, h_inc=300, δ=500 (Refer to SATLike3.0).

Table 1 shows the experimental results of SATLike3.0 before and after parameter tuning.

BandMaxSAT:

d: the reward delay steps,

γ: the reward discount factor,

$ArmNum$: the number of sampled arms,

λ: the exploration bias parameter,

[1]We did not configure two SAT-based competitors (*i.e.,* Loandra and TT-Open-WBO-Inc), since they do not expose any configurable parameters.

Table 1: Experimental results of SATLike3.0(default) and SATLike3.0(configured) on all the PMS benchmarks.

Benchmark	#inst.	SATLike3.0(default)		SATLike3.0(configured)	
		#win.	time	#win.	time
PMS_2019	299	155	63.14	**185**	**56.02**
PMS_2020	262	131	64.21	**156**	**58.09**
PMS_2021	155	75	63.95	**81**	**54.72**

Table 2: Experimental results of BandMaxSAT(default) and BandMaxSAT(configured) on all the PMS benchmarks.

Benchmark	#inst.	BandMaxSAT(default)		BandMaxSAT(configured)	
		#win.	time	#win.	time
PMS_2019	299	163	66.94	**187**	69.98
PMS_2020	262	143	73.54	**158**	77.39
PMS_2021	155	69	58.81	**102**	92.35

Table 3: Experimental results of NuWLS-alt1(default) and NuWLS-alt1(configured) on all the PMS benchmarks.

Benchmark	#inst.	NuWLS-alt1(default)		NuWLS-alt1(configured)	
		#win.	time	#win.	time
PMS_2019	299	183	72.44	**197**	**67.43**
PMS_2020	262	158	70.87	**171**	73.77
PMS_2021	155	89	64.81	**102**	73.22

Table 4: Experimental results of NuWLS-alt2(default) and NuWLS-alt2(configured) on all the PMS benchmarks.

Benchmark	#inst.	NuWLS-alt2(default)		NuWLS-alt2(configured)	
		#win.	time	#win.	time
PMS_2019	299	163	60.20	163	**59.50**
PMS_2020	262	137	55.14	**141**	**54.91**
PMS_2021	155	68	44.48	**72**	53.26

h_inc: the increment for each falsified hard clause each time (This parameter does not participate in parameter tuning, as does NuWLS),

sp: the smooth probability of clause weights,

δ: whose value is the maximum weight of each soft clause,

t: the number of samples, used in BMS strategy.

h_inc is set according to BandMaxSAT. We used SMAC to automatically configure the remaining 7 parameters of BandMaxSAT.

For PMS benchmarks:

Default parameter settings: d=20, γ=0.9, $ArmNum$=20, λ=1. t=15, sp=0.01, h_inc=1, δ=1, iff the number of variables <1100; otherwise $t = 42$, sp=3e-6, h_inc=1, δ=400. (Refer to BandMaxSAT (Zheng et al. 2022)).

Configured parameter settings: d=43, γ=0.6, $ArmNum$ =11, λ=4.77. t=15, sp=0.01, h_inc=1, δ=1, iff the number of variables <1100; otherwise t=42, sp=5.5e-5, h_inc=1, δ=54.

For WPMS benchmarks:

No better parameters were found using SMAC than those in BandMaxSAT. d=20, γ=0.9, $ArmNum$=20, λ=1.0. t=15, sp=1e-7, h_inc=3, δ=1, iff soft clause average weight <10,000; otherwise t=15, sp=1e-7, h_inc=300, δ=500 (Refer to BandMaxSAT).

Table 2 shows the experimental results of BandMaxSAT before and after parameter tuning.

NuWLS-alt1:

NuWLS-alt1 default parameter settings: follow NuWLS's configured parameter settings.

For PMS benchmarks:

Configured parameter settings: h_sp=1.2e-4, s_sp=8.1e-5, δ=457, and t=55.

For WPMS benchmarks: No better parameters were found using SMAC.

The experimental results of NuWLS-alt1 before and after parameter tuning are shown in Table 3.

NuWLS-alt2:

NuWLS-alt2 default parameter settings: follow NuWLS's configured parameter settings.

For PMS benchmarks:

Configured parameter settings: h_sp=1.6e-4, δ=330, and t=38.

For WPMS benchmarks: No better parameters were found using SMAC.

The experimental results of NuWLS-alt2 before and after parameter tuning are shown in Table 4.

References

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Zheng, J.; He, K.; Zhou, J.; Jin, Y.; Li, C.-M.; and Manya, F. 2022. BandMaxSAT: A Local Search MaxSAT Solver with Multi-armed Bandit. In *The Thirty-First International Joint Conference on Artificial Intelligence*.

Table 5: Results of NuWLS for solving PMS benchmarks under different parameter settings.

Parameter settings num.	h_{sp}	s_{sp}	δ	t	2019 #win.	2020 #win.	2021 #win.
P0	0.0002	0.000066	183	96	194	166	67
P1	0.001	0.0001	50	10	183	155	61
P2	0.001	0.0001	50	50	184	159	65
P3	0.001	0.0001	50	100	190	166	63
P4	0.001	0.0001	100	10	185	155	62
P5	0.001	0.0001	100	50	187	157	63
P6	0.001	0.0001	100	100	190	164	64
P7	0.001	0.0001	500	10	183	156	62
P8	0.001	0.0001	500	50	188	160	64
P9	0.001	0.0001	500	100	191	164	65
P10	0.001	0.00001	50	10	190	161	65
P11	0.001	0.00001	50	50	195	165	64
P12	0.001	0.00001	50	100	195	168	70
P13	0.001	0.00001	100	10	184	159	64
P14	0.001	0.00001	100	50	192	159	65
P15	0.001	0.00001	100	100	189	165	69
P16	0.001	0.00001	500	10	184	156	62
P17	0.001	0.00001	500	50	190	164	62
P18	0.001	0.00001	500	100	189	167	69
P19	0.0001	0.0001	50	10	188	160	69
P20	0.0001	0.0001	50	50	194	172	68
P21	0.0001	0.0001	50	100	189	164	66
P22	0.0001	0.0001	100	10	189	159	69
P23	0.0001	0.0001	100	50	187	162	69
P24	0.0001	0.0001	100	100	187	164	71
P25	0.0001	0.0001	500	10	192	161	69
P26	0.0001	0.0001	500	50	191	168	66
P27	0.0001	0.0001	500	100	193	164	69
P28	0.0001	0.00001	50	10	194	164	76
P29	0.0001	0.00001	50	50	198	169	68
P30	0.0001	0.00001	50	100	191	166	69
P31	0.0001	0.00001	100	10	188	162	71
P32	0.0001	0.00001	100	50	196	167	66
P33	0.0001	0.00001	100	100	193	168	70
P34	0.0001	0.00001	500	10	187	162	72
P35	0.0001	0.00001	500	50	198	170	68
P36	0.0001	0.00001	500	100	187	167	69

Table 6: Results of NuWLS for solving WPMS benchmarks under different parameter settings.

Parameter settings num.	h_{sp}	s_{sp}	δ	t	2019 #win.	2020 #win.	2021 #win.
P0	0.000068	0.00000099	200	25	123	98	58
P1	0.0001	0.000001	50	10	122	94	55
P2	0.0001	0.000001	50	50	122	96	56
P3	0.0001	0.000001	50	100	129	98	57
P4	0.0001	0.000001	100	10	126	95	58
P5	0.0001	0.000001	100	50	122	102	58
P6	0.0001	0.000001	100	100	123	95	61
P7	0.0001	0.000001	500	10	114	86	61
P8	0.0001	0.000001	500	50	120	94	61
P9	0.0001	0.000001	500	100	119	91	58
P10	0.0001	0.0000001	50	10	120	97	55
P11	0.0001	0.0000001	50	50	126	101	55
P12	0.0001	0.0000001	50	100	120	93	55
P13	0.0001	0.0000001	100	10	125	95	58
P14	0.0001	0.0000001	100	50	120	102	56
P15	0.0001	0.0000001	100	100	125	91	55
P16	0.0001	0.0000001	500	10	117	87	58
P17	0.0001	0.0000001	500	50	118	93	59
P18	0.0001	0.0000001	500	100	116	89	59
P19	0.00001	0.000001	50	10	111	88	53
P20	0.00001	0.000001	50	50	119	96	54
P21	0.00001	0.000001	50	100	118	87	52
P22	0.00001	0.000001	100	10	113	91	57
P23	0.00001	0.000001	100	50	116	88	55
P24	0.00001	0.000001	100	100	115	86	53
P25	0.00001	0.000001	500	10	104	84	55
P26	0.00001	0.000001	500	50	110	83	50
P27	0.00001	0.000001	500	100	110	85	55
P28	0.00001	0.0000001	50	10	115	92	52
P29	0.00001	0.0000001	50	50	116	91	52
P30	0.00001	0.0000001	50	100	115	84	51
P31	0.00001	0.0000001	100	10	106	83	59
P32	0.00001	0.0000001	100	50	114	90	56
P33	0.00001	0.0000001	100	100	113	85	54
P34	0.00001	0.0000001	500	10	109	84	57
P35	0.00001	0.0000001	500	50	108	84	53
P36	0.00001	0.0000001	500	100	114	83	58