Supplementary Material

Golden Parameter Search

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ABSTRACT

Supplementary Material for "Golden Parameter Search: Exploiting Structure to Quickly Configure Parameters In Parallel" [1]. Includes tables with complete results for all configuration scenarios in our experiments with small and large parallel time budgets.

CCS CONCEPTS

• **Computing methodologies** → **Artificial intelligence**; **Search methodologies**; *Machine learning*; Parallel computing methodologies;

KEYWORDS

Automated Algorithm Configuration, Parallel Algorithm Configuration, Parameter Turning, Hyper-Parameter Optimization

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A EXTENDED EXPERIMENTAL RESULTS

In Table 1 we show the results from performing the large parallel budget analysis (see Section 4 in the original paper) for all of the anytime configurations that we evaluated. In Table 2 we show the same results, but using the small parallel budget analysis (see Section 4 in the original paper). In both of these tables, we mark in boldface the configurations with speedups that are not statistically worse than the best speedup within each cell, according to a permutation test with a 5% significance level.

While each configuration procedure had the same total configuration budget within in cell, this does mean that they all required the same amount of time to validate the configurations. Table 1 shows the total wall clock time (in hours) for configuration and validation for our large parallel budget analysis. These numbers assume that the validation times can be perfectly parallelized using the same number of processors as used during configuration. We also show the same results for the small parallel budget analysis in Table 2. However, we note that in this case, since SMAC is the only configurator that requires validation of a set of configurations, all the other methods required exactly the configuration budget times. Rather than highlighting the configurators which had the smallest validation times, in these tables we mark in boldface the corresponding entries to the tables above. That is, to compare the configuration + validation budget of only the configurators which found the best configurations, one only needs to look at the budgets that are marked in boldface.

REFERENCES

[1] Yasha Pushak and Holger H. Hoos. 2020. Golden Parameter Search: Exploiting Structure to Quickly Configure Parameters in Parallel. In *Proceedings of the Twenty-Second International Genetic and Evolutionary Computation Conference (GECCO 2020).* 245–253.

Table 1: Large Parallel Budget Analysis Speedups (Median and 95% Confidence Interval)

	TSP		SAT		MIP	
	LKH	EAX	CaDiCaL	probSAT	CPLEX	
	TSP RUE 1000-3000		Circuit Fuzz	7SAT90	Regions200	RCW2
Configuration budget (excluding validation) = 0.5 wall clock hours						
GPS	**1.00** [0.92, 1.05]	2.13 [2.13, 3.55]	1.11 [1.00, 1.33]	2.26 [2.26, 2.26]	**1.03** [1.00, 1.03]	1.03 [0.99, 1.05]
SMAC3.0	**1.00** [1.00, 1.00]	**2.83** [2.49, 2.95]	**1.25** [1.09, 1.36]	**6.72** [5.57, 16.60]	**1.00** [0.95, 1.22]	**1.26** [1.21, 1.27]
irace3.3	**1.00** [1.00, 1.00]	**2.67** [2.08, 2.81]	0.94 [0.13, 0.94]	**9.50** [4.91, 9.50]	**1.00** [0.01, 1.00]	1.00 [1.00, 1.00]
GGA++	0.59 [0.37, 0.72]	0.61 [0.61, 0.61]	0.84 [0.75, 0.85]	**7.30** [5.86, 8.89]	–	–
Configuration budget (excluding validation) = 1.0 wall clock hours						
GPS	**0.99** [0.92, 1.00]	**3.14** [3.05, 3.38]	1.11 [1.00, 1.33]	2.26 [2.26, 3.76]	**1.00** [1.00, 1.05]	1.04 [0.99, 1.05]
SMAC3.0	**1.00** [1.00, 1.00]	**2.63** [2.49, 3.10]	**1.33** [1.16, 1.36]	**7.10** [6.72, 16.60]	**1.00** [0.85, 1.02]	**1.26** [1.21, 1.27]
irace3.3	**1.00** [1.00, 1.00]	**2.81** [2.67, 3.09]	0.68 [0.13, 0.94]	**6.92** [4.91, 9.50]	0.37 [0.01, 1.00]	1.00 [1.00, 1.00]
GGA++	0.60 [0.43, 0.65]	0.61 [0.61, 0.61]	0.85 [0.75, 1.02]	**7.30** [5.86, 8.89]	–	–
Configuration budget (excluding validation) = 3.0 wall clock hours						
GPS	**1.00** [0.94, 1.20]	**3.05** [2.36, 3.21]	**1.35** [1.00, 1.44]	3.76 [1.93, 4.73]	**1.05** [0.95, 1.30]	1.05 [1.00, 1.05]
SMAC3.0	**1.00** [1.00, 1.00]	**2.65** [2.62, 3.55]	**1.25** [1.09, 1.36]	**7.73** [4.28, 13.41]	**1.00** [0.91, 1.18]	**1.26** [1.22, 1.27]
irace3.3	**1.00** [0.76, 1.00]	2.17 [2.17, 2.81]	0.87 [0.84, 0.98]	**7.01** [4.81, 8.95]	**1.00** [0.01, 1.00]	1.00 [1.00, 1.00]
GGA++	0.72 [0.54, 1.01]	0.61 [0.61, 0.61]	0.89 [0.81, 1.02]	**7.30** [5.86, 8.89]	–	–
Configuration budget (excluding validation) = 6.0 wall clock hours						
GPS	**1.20** [0.95, 1.20]	**3.05** [2.82, 3.21]	**1.41** [1.12, 1.41]	**3.76** [1.93, 4.73]	**1.16** [1.00, 1.31]	1.01 [1.00, 1.05]
SMAC3.0	1.00 [1.00, 1.00]	**2.62** [2.53, 3.55]	1.25 [1.09, 1.36]	**4.90** [4.28, 13.41]	0.96 [0.77, 1.18]	**1.26** [1.22, 1.27]
irace3.3	0.94 [0.92, 1.11]	2.48 [1.85, 3.38]	0.87 [0.83, 0.95]	**4.90** [4.90, 13.06]	0.01 [0.01, 1.00]	1.00 [1.00, 1.00]
GGA++	0.66 [0.58, 1.05]	0.61 [0.61, 0.61]	0.92 [0.89, 1.02]	**7.14** [5.38, 8.58]	–	–
Configuration budget (excluding validation) = 12.0 wall clock hours						
GPS	**1.20** [1.01, 1.22]	**3.21** [2.82, 3.21]	**1.51** [1.31, 1.54]	3.03 [1.93, 5.52]	0.14 [0.14, 0.18]	1.11 [1.00, 1.33]
SMAC3.0	1.00 [1.00, 1.00]	**2.93** [2.62, 3.08]	1.26 [1.16, 1.36]	**4.90** [4.28, 13.41]	**1.18** [0.78, 1.23]	**1.26** [1.22, 1.27]
irace3.3	1.03 [0.79, 1.14]	**2.72** [2.33, 3.00]	0.90 [0.84, 1.01]	**5.86** [4.97, 12.92]	1.00 [0.01, 1.00]	1.00 [1.00, 1.00]
GGA++	1.01 [0.77, 1.01]	0.61 [0.61, 0.61]	0.91 [0.87, 1.02]	**8.87** [4.35, 19.84]	–	–
Configuration budget (excluding validation) = 24.0 wall clock hours						
GPS	**1.21** [1.18, 1.28]	**3.22** [2.36, 3.46]	**1.44** [1.16, 1.55]	3.03 [1.93, 5.52]	0.68 [0.01, 1.12]	**1.41** [1.09, 1.41]
SMAC3.0	1.00 [1.00, 1.00]	2.73 [2.62, 3.08]	**1.36** [1.16, 1.60]	**5.76** [4.28, 13.41]	**1.18** [0.77, 1.23]	1.26 [1.22, 1.27]
irace3.3	1.03 [0.79, 1.14]	2.72 [2.33, 3.00]	0.90 [0.84, 1.01]	**5.86** [4.97, 12.92]	0.01 [0.01, 1.00]	1.00 [1.00, 1.00]
GGA++	1.02 [0.77, 1.11]	0.61 [0.61, 0.61]	1.02 [0.84, 1.02]	**8.87** [6.73, 8.89]	–	–

Table 2: Small Parallel Budget Analysis Speedups (Median and 95% Confidence Interval)

	TSP		SAT		MIP	
	LKH	EAX	CaDiCaL	probSAT	CPLEX	
	TSP RUE 1000-3000		Circuit Fuzz	7SAT90	Regions200	RCW2
Configuration budget (excluding validation) = 0.5 wall clock hours						
GPS	**0.95** [0.92, 1.05]	2.13 [2.13, 3.55]	1.01 [1.00, 1.33]	2.26 [1.00, 2.26]	**1.00** [0.88, 1.03]	1.00 [0.99, 1.05]
SMAC3.0	**1.00** [1.00, 1.00]	**2.83** [2.46, 3.36]	**1.19** [1.01, 1.36]	**8.24** [5.36, 16.60]	0.96 [0.24, 1.22]	**1.22** [1.00, 1.27]
irace3.3	**1.00** [1.00, 1.00]	**2.59** [1.85, 2.81]	0.13 [0.13, 0.94]	**6.78** [4.67, 9.50]	0.01 [0.00, 1.00]	1.00 [1.00, 1.00]
GGA++	0.46 [0.37, 0.72]	0.61 [0.61, 0.61]	0.84 [0.52, 0.85]	**6.61** [3.49, 8.89]	–	–
Configuration budget (excluding validation) = 1.0 wall clock hours						
GPS	**0.99** [0.92, 1.00]	**3.14** [2.27, 3.38]	1.01 [1.00, 1.33]	2.26 [1.32, 3.76]	**1.00** [0.88, 1.05]	1.00 [0.99, 1.05]
SMAC3.0	**1.00** [1.00, 1.00]	**2.68** [2.40, 3.36]	**1.19** [1.01, 1.36]	**7.73** [5.37, 16.60]	0.96 [0.30, 1.02]	**1.22** [1.00, 1.27]
irace3.3	**1.00** [1.00, 1.00]	**2.76** [2.19, 3.09]	0.13 [0.13, 0.94]	**6.78** [4.67, 9.50]	0.01 [0.00, 1.00]	1.00 [1.00, 1.00]
GGA++	0.50 [0.43, 0.65]	0.61 [0.61, 0.61]	0.76 [0.52, 1.02]	**6.61** [3.49, 8.89]	–	–
Configuration budget (excluding validation) = 3.0 wall clock hours						
GPS	**1.00** [0.94, 1.20]	**3.05** [2.36, 3.21]	1.12 [1.00, 1.44]	2.26 [1.32, 4.73]	**1.01** [0.90, 1.30]	1.00 [0.98, 1.05]
SMAC3.0	**1.00** [1.00, 1.00]	**2.68** [2.62, 3.55]	**1.19** [1.01, 1.36]	**8.25** [4.28, 13.41]	**0.98** [0.46, 1.18]	**1.22** [1.00, 1.27]
irace3.3	**1.00** [0.76, 1.05]	2.57 [2.17, 2.81]	0.85 [0.71, 0.98]	**7.01** [4.81, 9.03]	0.01 [0.00, 1.00]	1.00 [1.00, 1.00]
GGA++	0.58 [0.46, 1.01]	0.61 [0.61, 0.61]	0.85 [0.78, 1.02]	**6.61** [3.49, 8.89]	–	–
Configuration budget (excluding validation) = 6.0 wall clock hours						
GPS	**1.01** [0.95, 1.20]	**3.03** [2.36, 3.21]	**1.31** [1.08, 1.41]	3.03 [1.32, 4.73]	0.65 [0.20, 1.21]	1.00 [0.99, 1.05]
SMAC3.0	**1.00** [1.00, 1.00]	**2.75** [2.53, 3.55]	1.19 [1.01, 1.36]	**5.47** [4.28, 13.42]	**1.18** [0.62, 1.55]	**1.22** [1.00, 1.27]
irace3.3	**0.94** [0.86, 1.11]	2.33 [1.85, 3.38]	0.85 [0.80, 0.95]	**5.59** [4.90, 13.06]	0.15 [0.06, 1.00]	1.00 [0.00, 1.00]
GGA++	0.66 [0.58, 1.05]	0.61 [0.61, 0.61]	0.90 [0.82, 1.02]	**5.70** [5.36, 8.58]	–	–
Configuration budget (excluding validation) = 12.0 wall clock hours						
GPS	**1.12** [0.89, 1.22]	**3.03** [2.36, 3.21]	**1.36** [1.23, 1.54]	3.03 [1.51, 5.52]	0.14 [0.01, 0.18]	1.09 [0.96, 1.33]
SMAC3.0	**1.00** [1.00, 1.00]	**2.89** [2.62, 3.28]	1.19 [1.01, 1.36]	**6.82** [4.28, 13.42]	0.83 [0.21, 1.23]	**1.22** [1.00, 1.27]
irace3.3	0.91 [0.79, 1.14]	**2.52** [2.33, 3.00]	0.87 [0.84, 1.01]	**5.86** [4.97, 12.92]	0.01 [0.00, 1.00]	1.00 [0.00, 1.00]
GGA++	0.82 [0.61, 1.01]	0.61 [0.61, 0.61]	0.88 [0.81, 1.02]	**7.08** [4.35, 19.84]	–	–
Configuration budget (excluding validation) = 24.0 wall clock hours						
GPS	**1.20** [1.18, 1.28]	**2.96** [2.36, 3.46]	**1.44** [1.16, 1.55]	3.03 [1.51, 5.52]	0.14 [0.11, 1.08]	1.17 [1.05, 1.41]
SMAC3.0	1.00 [1.00, 1.00]	**2.75** [2.62, 3.12]	1.23 [1.00, 1.60]	**7.73** [4.28, 13.42]	**0.96** [0.44, 1.01]	**1.22** [1.00, 1.27]
irace3.3	0.91 [0.79, 1.14]	**2.52** [2.33, 3.00]	0.87 [0.84, 1.01]	**5.86** [4.97, 12.92]	0.15 [0.06, 1.00]	1.00 [0.00, 1.00]
GGA++	0.86 [0.70, 1.11]	0.61 [0.61, 0.61]	0.89 [0.84, 1.02]	**6.98** [5.70, 8.89]	–	–

Table 3: Median Configuration Budget + Validation Time - Large Parallel Budget Analysis

	TSP		SAT		MIP	
	LKH TSP RUE	EAX 1000-3000	CaDiCaL Circuit Fuzz	probSAT 7SAT90	CPLEX Regions200	RCW2
Configuration budget (excluding validation) = 0.5 wall clock hours						
GPS	**0.59**	0.58	1.06	1.01	**2.21**	0.91
SMAC3.0	**1.13**	**1.19**	**5.40**	**2.64**	**129.63**	**13.78**
irace3.3	**0.58**	**0.58**	2.80	**0.75**	**31.94**	0.92
GGA++	0.63	0.65	1.30	**0.74**	–	–
Configuration budget (excluding validation) = 1.0 wall clock hours						
GPS	**1.09**	**1.08**	1.56	1.41	**2.71**	1.41
SMAC3.0	**1.63**	**1.66**	**5.86**	**2.97**	**130.57**	**14.28**
irace3.3	**1.08**	**1.08**	3.30	**1.25**	43.03	1.42
GGA++	1.13	1.15	1.77	**1.24**	–	–
Configuration budget (excluding validation) = 3.0 wall clock hours						
GPS	**3.09**	**3.08**	**3.53**	3.38	**4.71**	3.42
SMAC3.0	**3.63**	**3.63**	**7.80**	**5.03**	**136.23**	**16.28**
irace3.3	**3.09**	3.08	3.70	**3.22**	**45.03**	3.42
GGA++	3.11	3.15	3.69	**3.24**	–	–
Configuration budget (excluding validation) = 6.0 wall clock hours						
GPS	**6.09**	**6.08**	**6.51**	**6.38**	7.64	6.42
SMAC3.0	6.63	**6.62**	10.78	**7.95**	145.79	**19.28**
irace3.3	6.09	6.08	6.70	**6.22**	48.03	6.42
GGA++	6.11	6.15	6.68	**6.24**	–	–
Configuration budget (excluding validation) = 12.0 wall clock hours						
GPS	**12.08**	**12.08**	**12.46**	12.38	25.27	12.39
SMAC3.0	12.63	**12.62**	16.75	**13.88**	**180.50**	**25.28**
irace3.3	12.10	**12.08**	12.67	**12.22**	54.03	12.42
GGA++	12.10	12.15	12.68	**12.27**	–	–
Configuration budget (excluding validation) = 24.0 wall clock hours						
GPS	**24.08**	**24.08**	**24.47**	24.38	24.38	**24.36**
SMAC3.0	24.63	24.62	**28.68**	**25.86**	**199.97**	37.27
irace3.3	24.10	24.08	24.68	**24.22**	66.03	24.42
GGA++	24.10	24.15	24.65	**24.23**	–	–

Table 4: Median Configuration Budget + Validation Time - Small Parallel Budget Analysis

	TSP		SAT		MIP	
	LKH TSP RUE	EAX 1000-3000	CaDiCaL Circuit Fuzz	probSAT 7SAT90	CPLEX Regions200	RCW2
Configuration budget (excluding validation) = 0.5 wall clock hours						
GPS	**0.50**	0.50	0.50	0.50	**0.50**	0.50
SMAC3.0	**1.13**	**1.19**	**5.41**	**2.61**	120.33	**13.79**
irace3.3	**0.50**	**0.50**	0.50	**0.50**	0.50	0.50
GGA++	0.50	0.50	0.50	**0.50**	–	–
Configuration budget (excluding validation) = 1.0 wall clock hours						
GPS	**1.00**	**1.00**	1.00	1.00	**1.00**	1.00
SMAC3.0	**1.63**	**1.66**	**5.85**	**2.92**	125.51	**14.29**
irace3.3	**1.00**	**1.00**	1.00	**1.00**	1.00	1.00
GGA++	1.00	1.00	1.00	**1.00**	–	–
Configuration budget (excluding validation) = 3.0 wall clock hours						
GPS	**3.00**	**3.00**	3.00	3.00	**3.00**	3.00
SMAC3.0	**3.63**	**3.63**	**7.79**	**4.98**	**126.26**	**16.27**
irace3.3	**3.00**	3.00	3.00	**3.00**	3.00	3.00
GGA++	3.00	3.00	3.00	**3.00**	–	–
Configuration budget (excluding validation) = 6.0 wall clock hours						
GPS	**6.00**	**6.00**	**6.00**	6.00	**6.00**	6.00
SMAC3.0	**6.63**	**6.62**	10.76	**7.91**	145.31	**19.28**
irace3.3	**6.00**	6.00	6.00	**6.00**	6.00	6.00
GGA++	6.00	6.00	6.00	**6.00**	–	–
Configuration budget (excluding validation) = 12.0 wall clock hours						
GPS	**12.00**	**12.00**	**12.00**	12.00	12.00	12.00
SMAC3.0	**12.63**	**12.62**	16.74	**13.85**	173.50	**25.29**
irace3.3	12.00	**12.00**	12.00	**12.00**	12.00	12.00
GGA++	12.00	12.00	12.00	**12.00**	–	–
Configuration budget (excluding validation) = 24.0 wall clock hours						
GPS	**24.00**	**24.00**	**24.00**	24.00	24.00	24.00
SMAC3.0	24.63	**24.62**	28.68	**25.81**	198.42	**37.28**
irace3.3	24.00	**24.00**	24.00	**24.00**	24.00	24.00
GGA++	24.00	24.00	24.00	**24.00**	–	–