Supplemental Material for: Automatic Extraction of Axioms for Planning

Submission 2332

Abstract

This is the supplemental material for Submission 2332, "Automatic Extraction of Axioms for Planning".

1 Proofs for Section 3: tau-Axiom Extraction

Theorem 1. Given a set of operators T, if every operator in T is dominated by every operator in $\bar{T}$, then T is the set of tau operators.

Proof. Let T be a set of operators such that every operator in T is dominated by every operator in $\bar{T}$. Given a state s, a pair of states $s', s'' \in T(s)$ and an operator $o \in \bar{T}$, assume $o(s') \neq o(s'')$. Since o is applicable in both s' and s'', s' and s'' must have the same values for all variables in $pre(o)$, and there must exist some variable v not in $pre(o)$ whose value differs in s' and s''. However, by the definition of dominance, operators in T cannot change the values of variable not in pre(o), so there can be no such v, a contradiction. □

Lemma 1. For every state $A(s)$ in Π', $a_{\{v_1=x_1,...,v_n=x_n\}} = 1$ if and only if $\{v_1 = x_1, ..., v_n = x_n\}$ is achievable from s in the original problem Π using only tau operators .

Proof. We show this by induction. For $\{v_1 = x_1, ..., v_n = x_n\}$ which is already true in $A(s)$, the lemma holds due to the axiom $a_{\{v_1=x_1,...,v_n=x_n\}} \leftarrow v_1 = x_1, ..., v_n = x_n$. If the lemma holds for every $\{v_1 = x_1, ..., v_n = x_n\}$ achievable in less than k steps, it also holds for every $\{v_1 = x_1, ..., v_n = x_n\}$ achievable in less than k+1 steps because of an axiom $a_{\{v_1=x'_1,...,v_n=x'_n\}} \leftarrow a_{\{v_1=x_1,...,v_n=x_n\}}, v_{n+1} = x_{n+1}, ..., v_m = x_m$. □

Theorem 2. Π' has a plan if and only if Π has a plan.

Proof. If Π has a plan p, an encoded plan p' with all tau operators removed is a plan for Π'. For every two adjacent operators o'_i, o'_j in p', there is a sequence of operators that leads from $A(o_i(, ..., o_1(A(I))))$ to a state where o_j is applicable in Π. Since o_j and o'_j share preconditions bar assignments on V_{tau}, we only need to confirm if $a_{\{v_1=x_1,...,v_n=x_n\}}$ is true. This can be confirmed by Lemma 1. Likewise, it is easy to show that p' also achieves the goals.

On the other hand, if Π' has a plan p', there is also a plan p for Π. p has operators corresponding to p' except that two adjacent operators o_i, o_j might not be executable in Π. Since $a_{\{v_1=x_1,...,v_n=x_n\}}$ is true when applying o'_j in p', by Lemma 1, we can always fill the gap between o_i and o_j with tau operators to obtain a plan p. By the definition of tau operators, how we fill the gap does not affect later steps. □

2 Detailed Results for Section 7: Improving Planer Performance Using Extracted Axioms

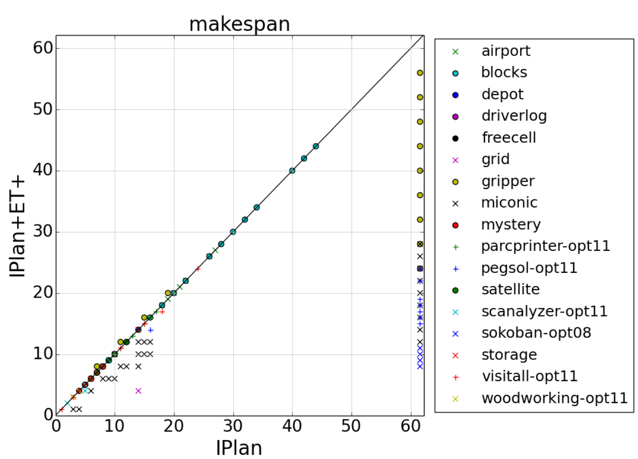

Figure S1: Makespan (n) comparisonper instance for IPlan vs. IPlan+ET+.

Table S1 is an extended version of Table 2, which includes the time spent in decoding and the average makespan n (the step at which the solution was found) for each configuration. Figure S1 is a detailed (per-instance) comparison of makespan for IPlan vs. IPlan+ET+.

Domain	Optiplan		Iplan		IplanS		Iplan+T			Iplan+T+			Iplan+E		Iplan+ET			Iplan+ET+		
	#	n	#	n	#	n	#	n	decode	#	n	decode	#	n	#	n	decode	#	n	decode
Domains with tau axioms only																				
miconic(150)	28	9.04	29	9.04	25	10.44	70	5.80	1.85	70	5.80	1.83	25	10.44	70	5.80	1.90	70	5.80	1.88
pegsol-opt11(20)	1	16.00	1	16.00	2	16.00	17	14.00	1.43	17	14.00	1.44	2	16.00	17	14.00	1.38	17	14.00	1.38
satellite(36)	8	8.67	8	8.67	3	11.00	3	11.00	None	8	8.67	None	3	11.00	3	11.00	None	8	8.67	None
scanalyzer-opt11(20)	11	4.33	11	4.33	4	7.67	4	7.33	0.41	11	4.00	0.62	3	7.67	3	7.33	0.41	11	4.00	0.61
Domains with exactly-1 axioms only																				
barman-opt14(14)	0	None	0	None	0	None	0	None	None	0	None	None	0	None	0	None	None	0	None	None
blocks(35)	16	15.75	29	15.75	29	15.75	29	15.75	None	29	15.75	None	32	15.75	32	15.75	None	29	15.75	None
depot(22)	7	6.50	11	6.50	2	12.50	2	12.50	None	11	6.50	None	2	12.50	2	12.50	None	11	6.50	None
driverlog(20)	11	6.00	11	6.00	4	10.75	4	10.75	None	11	6.00	None	4	10.75	4	10.75	None	11	6.00	None
freecell(80)	18	6.00	18	6.00	7	9.14	7	9.14	None	18	6.00	None	9	9.14	9	9.14	None	18	6.00	None
mystery(30)	13	5.08	16	5.08	14	5.58	14	5.58	None	16	5.08	None	13	5.58	13	5.58	None	16	5.08	None
parcprinter-opt11(20)	20	11.33	20	11.33	12	28.92	12	28.92	None	20	11.33	None	12	28.92	12	28.92	None	20	11.33	None
parking-opt14(20)	0	None	0	None	0	None	0	None	None	0	None	None	0	None	0	None	None	0	None	None
storage(30)	9	6.14	9	6.14	7	6.71	7	6.71	None	9	6.14	None	7	6.71	7	6.71	None	9	6.14	None
tidybot-opt14(20)	0	None	0	None	0	None	0	None	None	0	None	None	0	None	0	None	None	0	None	None
woodworking-opt11(20)	20	3.10	20	3.10	10	14.30	10	14.30	None	20	3.10	None	10	14.30	10	14.30	None	20	3.10	None
Domains with both exactly-1 axioms and tau axioms																				
airport(50)	13	15.14	16	15.14	7	16.29	7	16.29	0.07	16	15.14	0.07	7	16.29	7	16.29	0.12	16	15.14	0.12
grid(5)	1	14.00	1	14.00	1	14.00	1	4.00	0.72	1	4.00	0.72	1	14.00	1	4.00	0.66	1	4.00	0.67
gripper(20)	4	9.00	4	9.00	2	14.00	8	10.00	1.55	8	10.00	1.67	2	14.00	13	10.00	2.51	13	10.00	2.51
sokoban-opt08(30)	0	None	0	None	0	None	0	None	None	0	None	None	1	None	5	None	1.25	5	None	1.23
visitall-opt11(20)	8	10.75	8	10.75	10	10.75	9	10.62	0.12	9	10.62	0.10	9	10.75	8	10.62	0.12	8	10.62	0.10
all(662)	188	9.22	212	9.22	139	13.03	204	11.88	1.51	274	8.45	1.51	142	13.03	216	11.88	1.64	283	8.45	1.63

Table S1: IPlan Results: for each method, #= number of instances solved within resource limit (5min, 2GB), n = average makespan (the first step the solution was found) for instances all the configurations solved, decode = average time needed for decoding