ACTION, ABDUCTION AND PLAN RECOGNITION

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Abstract. In the forthcoming distributed autonomous robotic systems it will be
robot to recognize other robots' goals and plans from visual information. Ti
emphasis has been given to plan inference. This paper is about *goal recogniti*
recognised a plan (may be after the entire plan has been performed), try to rec
be the actor's reasons for the plan to be performed. If the actor's planner pos
inferential capabilities, then goal recognition is not a trivial question. This pa
under simple hypotheses on the nature of the planner that guides an actor'
observer can recognize the actor's goal by means of a simple *clause-based abductive r*
Furthermore, the paper shows how goal recognition can be regarded as a use
inference. This results refer to the prototypical state-based STRIPS planner.

1. INTRODUCTION

Many people in the Artificial Intelligence community have shown the impor *recognition* as inferring the other agents' plans from their partially performed or p portions [Carberry 90] [Kautz 90] [Charniak 93]; see [Carberry 93] for a good o subject. In Distributed Artificial Intelligence [Bond 88] it is widely accepted cooperative interaction depends upon agents reasoning about one anothers' gc plan is a sequence of actions that can be expected to allow an agent to reach There is no bijective correspondence between plans and goals because, in ger plan can be performed to achieve different goals and the same goal can be ac different plans (Fig 1). Furthermore, the same sequence of actions can be regar plans if performed in different situations; for instance, if you are in a big depa same action "go upstairs" can represent a "plan to go to the bank" or a "p restaurant" or whatever else plan depending on the floor you are on when you s

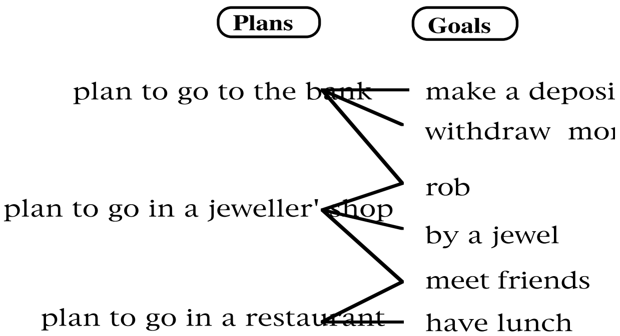

Fig 1. There is no bijective correspondence between plans and goals

This paper is about *goal recognition*: having recognised a plan (may be after the en been performed), try to recognise which were the reasons for the plan to be p planner possesses sufficient inferential abilities, then the plan's goal could be n adding and/or removing the facts explicitly listed in the operators' definitior some state of affairs that will be implied by these changes; in other words, the plan could be some "logical consequence(s)" of the changes made in the world b the plan, particularly the last one (Fig. 2). If this is the case, then goal recognitic not a trivial question and this paper shows that it can be considered an abducti paper begins defining a class of logic-based abduction problem that fits partic recognition task. After a brief sentimental overview on the venerable STRIPS prove the abductive nature of the goal recognition task for a STRIPS-like systen why we refer to that old planner are the simplicity of its formal characterisa [Nilsson 81] as means to modify the state of the world by adding and/or remov representativeness over a large class of state-based planners. We think that STR plan inference and goal recognition the same foundational and archetypal role playing in plan synthesis during the last two decades. Finally, we show how gc can be regarded as a step in plan recognition since the goal of a partially perfor that of making performable the rest of the plan. This goal centered view of pla stand side by side with the classical approaches and it's a (small) step towa ambitious task of "mental state" recognition from visual information or commun acts") [Dragoni 94].

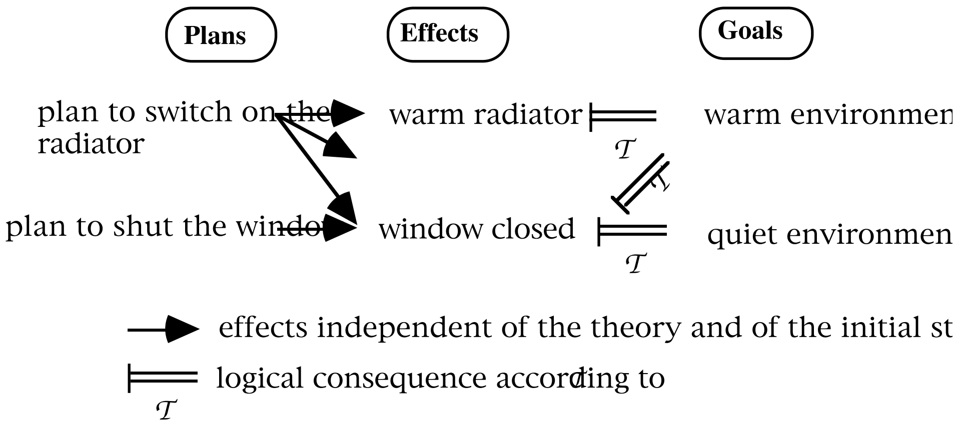

Fig 2. The plan's goal(s) can be some "logical consequence(s)" of the changes produced by

2. ABDUCTION

Abduction is generally presented as an abstract hypothetical inferential schei causal theory of the world (a set of formal rules or links between causes and ef of observations (facts that don't follow simply from the causal theory), tri *explanation* of the observed facts. An explanation is a set of hypothetical facts w with the causal theory, justifies the presence of the observed facts. Recently t various formal characterisations of abduction (see [Paul 93] for a complete ov subject). The following is a logic-based account for abduction.

Let $\mathcal{L}$ be a first order language and $\mathcal{T}$ be a logical theory defined over the lang and Ω be sets of sentences of $\mathcal{L}$ respectively called *abducible* and *observable*. A *logi abduction problem* (hereafter *logic-based a.p.*) is that of finding a *primitive explanation* $\varphi \in A$ an observation $\omega \in \Omega$ such that:

- $\mathcal{T} \cup \varphi \vdash \omega$ (1
- $\mathcal{T} \cup \varphi$ is consistent. (2

Thus, the observation ω must be derivable from the logical theory $\mathcal{T}$ augme explanation φ under the additional condition that φ is consistent with $\mathcal{T}$. Any primitive explanations for ω still verifies the 1 and 2 even if it doesn't belo suggests the following definition.

Definition 1. If a disjunction of primitive explanations doesn't belong to the ab
then it is said to be a *cautious* explanation for ω. If there are a finite number
explanations for ω then their disjunction is said *most cautious explanation*.

In this paper I'll refer to the following slight general definition of abduction.

Definition 2. Let $\mathcal{L}$ be a first order language and $\mathcal{T}$ be a logical theory definec
language $\mathcal{L}$. Let A, Ω and Σ be sets of sentences of $\mathcal{L}$ respectively called abducible
and *consistency* sets. A *strong logic-based* φ.a is that of finding a primitive explanation $\varphi\in$
an observation $\omega\in\Omega$ such that:

- $\mathcal{T}\cup\varphi \vdash \omega$
- $\mathcal{T}\cup\Sigma\cup\varphi$ is consistent.

When $\Sigma=\emptyset$, this strong pa reduces to a normal logic-based one. From a theoretical
view, the introduction of the consistency set Σ renders this definition of abduc
than the classical one in the sense that every explanation for it is also a normal
not vice-versa. In fact, because of the monotonicity of first order logic, if φ is c
$\mathcal{T}\cup\Sigma$ then φ is consistent with $\mathcal{T}$ too but not vice-versa. From a pragmatical poin
introduction of the consistency set Σ is almost uninfluent. In fact, a procedu
abductive explanations can be splitted in two subroutines: the first one takes $\mathcal{T}$ a
for an explanation φ, the second one checks for the consistency of φ with $\mathcal{T}$, b
checks for the consistency of φ with $\mathcal{T}\cup\Sigma$.

Let we particularize the preceding definition to the following clause-based an
ones. A *literal* is an atomic sentence of $\mathcal{L}$ or its negation. A *clause* is the disjunctio
literals of $\mathcal{L}$. Every set of clauses is logically equivalent to a wff and vice-versa.

Definition 3. Let $\mathcal{T}$ and Σ be sets of clauses of $\mathcal{L}$. Let Ω and A be sets of *ground*
of $\mathcal{L}$. A *clause-based* strong pa is that of finding a primitive explanation $\Phi\subseteq A$ of an obse
$O\subseteq\Omega$ such that

- $\mathcal{T}\cup\Sigma \nvdash \neg\Phi$, that is Φ is consistent with $\mathcal{T}\cup\Sigma$,
- $\mathcal{T}\cup\Phi \vdash O$,
- Φ is subset-minimal.

The last point of the definition embodies a selection criterion for "good" expl
[Allemang 91] is called "parsimony". It prevents the choice, as explanations, of
containing a proper subset that itself constitutes a valid explanation. If A is restr
of atomic sentences (clauses made of a single, *positive* literal) and if $\Sigma=\emptyset$, then this
a p collapses to the pa defined in [Konolige 92] and in [Reiter 87].

Definition 4. A *literal-based* strong ap is a clause-based strong ap in which the abducible set A is made of literals.

Although problematic from a pragmatical computational point of view, the conceptualization of clause-based ap, is conceptually stimulating because it provides f case in which, in order to explain some observations, it is not sufficient to hy facts but it is necessary to hypothesize the presence of other rules in the theor $\neg\beta\rightarrow\alpha$). It is this kind of abduction that (along with induction) is at the base of t of scientific theories.

There is no intrinsic relationship between the cardinalities of Φ and O. Depe theory $\mathcal{T}$, an explanation Φ can be a set of more than one clause even if O is ma clause and, vice-versa, a single clause can be an explanation of a set of clauses. S be useful to consider only explanations of a certain cardinality. To cope with useful the following definition.

Definition 5. An *n×m ap.* is a clause-based ap in which the cardinality of O is n and t cardinality of the explanations Φ is *forced* to be m.

It is well known that the evaluation of alternative explanations turns out to be of abduction. Global criteria as that of the "cardinality comparison" or that of ' inapplicable in problems in which the cardinality is fixed. Another global criteri *least presumptive explanation* [Poole 89]. Given a set of alternative explanations $\mathcal{F}$ problem $\mathcal{T}\cup\Phi O$, an explanation $\Phi_i \in \mathcal{F}$ is *less presumptive* than an explanation $\Phi_j \in$ $\mathcal{T}\cup\Phi_j \vdash \Phi_i$. This definition can be stressed making it independent of $\mathcal{T}$: $\Phi_i \in \mathcal{F}$ is *str* *presumptive* than an explanation $\Phi_j \in \mathcal{F}$ if $\Phi_j \vdash \Phi_i$. Given a clause-based ap, its most cautious explanation is the strongly *least* presumptive one. Obviously, if Φ_i is (stro presumptive than Φ_j, then Φ_j is said (strongly) *more* presumptive than Φ_i. In s fairness, global criteria seem to be insufficient to discriminate explanation a [Appelt 92] (p. 6) the authors suggest that some local metric criteria must be a "neither a most specific nor a least specific abduction strategy is completely app ascription". In [Charniak 93] is presented a Bayesian model of plan recognition.

3. ACTIONS

I refer to the semantic of STRIPS given in [Lifschitz 87]. A *state theory* T is a cons of sentences of $\mathcal{L}$. A *state model* M is any consistent set of ground atomic sentenc *world model* M^T is the consistent union of a state model M with a state theory T. A s represents the world where the robot is working in at a given instant. The represents constraints that must be verified in every instant. To simplify the n relations that must be verified between facts at different instants. An *operator de* triple (P, D, A), where P (the *preconditions*), D (the *delete list*) and A (the *add list*) are s *atomic* sentences of $\mathcal{L}$. If these atomic sentences contain variables then the operat actually represents a family of operator descriptions, one for each possible inst variables with the constants in $\mathcal{L}$.

A STRIPS system consists of an initial world model $M^T{}_0$, a set Op of symbo *operators*, and a family of operator descriptions$\{(P_\alpha,D_\alpha,A_\alpha)\}_{\alpha\in Op}$. Given a STRIPS sy *plan* is any finite sequence of operators. Each plan $\pi=(\alpha_1,..,\alpha_n)$ defines a sequer models $M^T{}_0$, $M^T{}_1$, .., $M^T{}_n$, where

$M^T{}_i=(M^T{}_{i-1}\setminus D_{\alpha_i})\cup A_{\alpha_i}$ $\quad$ $(i=1,..,n)$

We say that a plan $\pi=(\alpha_1,..,\alpha_n)$ is *accepted* by a STRIPS system if

$M^T{}_{i-1}\vdash P_{\alpha_i}$ $\qquad$ $(i=1,..,n)$

In this case $M^T{}_n$ is the result of executing π in $M^T{}_0$ and we denote it $\mathcal{R}(\pi)$. We world described by the language $\mathcal{L}$ as being, at any instant of time, in a certain *s* that the set of sentences satisfied in state s is closed under predicate logic.

Assumption 1. (The planner has complete and correct knowledge about the er and the effects of each action in the world, so ..) If the robot has already p action/plan then the intent of the action/plan cannot be a disjunction of literal or a conjunction of literals.

Definition 6. A goal G is a literal or a conjunction of literals of $\mathcal{L}$.

4. GOALS RECOGNITION

To simplify the matter (without loss of generality) let we begin with plans ma operator. Subsequently it is shown how a longer plan can be represented by a s operator. The results of this paper hold upon the following fundamental assump

Assumption 2. The planner is *correct* and *complete*, that is, if the planner ver sentence p in a world model M^T then $M^T \vdash p$, and if $M^T \models p$ then the planner is able to prove Furthermore, if the planner plans an operator α_i to pursue a goal G then:

$M^T{}_{i-1}\nvdash G$, G is not satisfied in $M^T{}_{i-1}$ $\qquad$ (1

$M^T{}_i \vdash G$, G is satisfied in $M^T{}_i$ $\qquad$ (2

Theorem 1. If a planner plans an operator $\alpha_i=(P_{\alpha_i},D_{\alpha_i},A_{\alpha_i})$ to pursue a goal G, problem to recognise the planner's goal in planning α_i is a 1×1 strong clause-bas $M^T{}_{i-1}\setminus D_{\alpha_i}$ as "theory", $\neg A_{\alpha_i}$ as "observation", D_{α_i} as "consistency set" and $\neg G$ as explanation.

Proof. Let $M^T{}_{i-1}$ be $m^T{}_{i-1} \cup D_{\alpha i}$ and $M^T{}_i$ be $m^T{}_{i-1} \cup A_{\alpha i}$. From the 1. and 2. it follows

$m^T{}_{i-1} \cup D_{\alpha i} \nvdash G$ (1a

$m^T{}_{i-1} \cup A_{\alpha i} \vdash G$ (2a

From the 2a. it follows:

$m^T{}_{i-1} \cup \neg G \vdash \neg A_{\alpha i}$ (2b

If we take Φ for $\neg G$, O for $\neg A_{\alpha i}$, Σ for $D_{\alpha i}$, and $\mathcal{T}$ for $m^T{}_{i-1}$ we obtain:

- $\mathcal{T} \cup \Sigma \nvdash \neg\Phi$,
- $\mathcal{T} \cup \Phi \vdash O$.

The "observation" O is made of a single clause because it's the negation of the explanation Φ is made of a single clause because it's to be intended as the negati which is a conjunction of literals, so this is a 1×1 a ❑

Example 1. In a classical block-world domain there are a table, three blocks an Consider the following instanced STRIPS operator (from [6])

α:	**putdown**_b1
P_α:	holding_b1
D_α:	holding_b1
A_α:	ontable_b1,clear_b1,handempty

along with the following (piece of) world model $M^T{}_0$:

M_0	holding_b1, ontable_b2, ontable_b3, clear_b2, clear_b3
T:	holding_b1 ∨ holding_b2 ∨ holding_b3 → ¬handempty
	on_b2_b1 ∨ on_b3_b1 → ¬clear_b1
	holding_b1 → ¬on_b1_b2 ∧ ¬on_b1_b3 ∧ ¬ontable_b1
	holding_b1 → ¬holding_b2 ∧ ¬holding_b3
	ontable_b1 ∧ ontable_b2 ∧ ontable_b3 → filled_table
	handempty → ontable_b1 ∨ on_b1_b2 ∨ on_b1_b3

Let STRIPS plan **putdown**_b1; $m^T{}_0 = T \cup \{$ontable_b2,ontable_b3, clear_b2, clear_b3$\}$, $D_{\alpha 1} = \{$holding_b1$\}$, $\neg A_{\alpha 1} = \{$¬ontable_b1 ∨ ¬clear_b1 ∨ ¬handempty$\}$. We obtain the following 1×1 a

- $T \cup \{$ontable_b2,ontable_b3, clear_b2, clear_b3$\} \cup \{$holding_b1$\} \nvdash \neg\Phi$
- $T \cup \{$ontable_b2,ontable_b3, clear_b2, clear_b3$\} \cup \Phi \vdash$ ¬ontable_b1 ∨ ¬clear_b1 ∨ ¬handempty

here are some single-clause single-literal explanations with their correspondent g

	Φ	G
1	¬ontable_b1	**ontable_b1**
2	¬clear_b1	**clear_b1**
3	¬handempty	**handempty**
4	holding_b1	**¬holding_b1**
5	¬filled_table	**filled_table**

[1] A set of sentences is logically equivalent to their conjunction and the negation of a conjunction of logically equivalent to the disjunction of their negations.

Goals 1÷3 are trivially the atoms in the add list, the others depend on the stat the initial state model and they couldn't be recognized without abduction.

The abducible set A is made of the negations of all the possible goals for planner. We can think of a possible goal as:

1. any conjunction of literals verified in $M^T{}_i$ but not in $M^T{}_{i-1}$ (1÷5-G in the examp
2. any conjunction of literals verified in $M^T{}_i$ but not in $M^T{}_{i-1}$ with any other lite both in $M^T{}_{i-1}$ and in $M^T{}_i$.

Correspondently, we can think of a possible single-clause explanation as:

1. any disjunction of literals verified in $M^T{}_i$ but not in $M^T{}_{i-1}$ (1÷5-Φ in the exampl
2. any disjunction of literals verified in $M^T{}_i$ but not in $M^T{}_{i-1}$ with the negation literal(s) verified both in $M^T{}_i$ and $M^T{}_{i-1}$.

We may admit only goals of type 1. In this case we can define the abducible set of all the ground literals of $\mathcal{L}$ and refer to the following result.

Theorem 2. If a planner plans an operator $\alpha_i=(P_{\alpha_i},D_{\alpha_i},A_{\alpha_i})$ to pursue a goal G, problem to recognise the planner's goal in planning α_i is a 1×1 strong *literal*-based $M^T{}_{i-1}\backslash D_{\alpha_i}$ as "theory", $\neg A_{\alpha_i}$ as "observation", D_{α_i} as "consistency set" and $\neg G$ as *p* *cautious* explanation .

Proof. Straightforward from the proof of the theorem 1 and the definitions 1 ; □

The set $\mathcal{G}$ of abducible goals can be sorted according to some domain indepe (for instance the number of literals in the goal) or domain dependent criteria importance of the goal); then a goal can be selected as the abducted one.

Let we move to the significant general case of plans longer than a single acti reason with STRIPS because its plans are simple sequences of operators and car themselves with operators.

Definition 7. For each plan $\Pi=(\alpha_1,..,\alpha_n)$ accepted by a STRIPS system we ((P_Π,D_Π,A_Π) its corresponding *composite operator* where:

$$P_\Pi= P_{\alpha 1} \cup P_{\alpha 2}\backslash A_{\alpha 1} \cup P_{\alpha 3}\backslash(A_{\alpha 1}\cup A_{\alpha 2}) \cup .. \cup P_{\alpha n}\backslash(A_{\alpha 1}\cup .. \cup A_{\alpha n-1})$$
$$A_\Pi= A_{\alpha n} \cup A_{\alpha n-1}\backslash D_{\alpha n} \cup A_{\alpha n-2}\backslash(D_{\alpha n}\cup D_{\alpha n-1}) .. \cup A_{\alpha 1}\backslash(D_{\alpha n}\cup .. \cup D_{\alpha 2})$$
$$D_\Pi= D_{\alpha n} \cup D_{\alpha n-1}\backslash A_{\alpha n} \cup D_{\alpha n-2}\backslash(A_{\alpha n}\cup A_{\alpha n-1}) .. \cup D_{\alpha 1}\backslash(A_{\alpha n}\cup .. \cup A_{\alpha 2})$$

The generalization of the preceding methods to the present case is straightfo we have to do is substitute the triple (P_Π,D_Π,A_Π) to the triple $(P_{\alpha_i},D_{\alpha_i},A_{\alpha_i})$, but sor be said about goals' plausibility. The set $\mathcal{G}$ of abducible goals of the overall pla can be sorted considering that the most important action in the plan should be t a soccer game every ball passing is functional to the last kick toward the goal, i each action is almost functional to the last one. However, those intermediate a

contribute to the final goal by achieving partial goals not vanished by subseque
plan. That's why we have to apply the goal recognition method to the
$\pi=(\alpha_1,..,\alpha_n)$, but we can then order the recognized goals from those reached by
to those accomplished by the action α_1.

5. PLAN RECOGNITION THROUGH GOALS RECOGNITION

If the executed plan is part of an unknown longer plan, then goal recognition as a useful step in plan recognition. Given a STRIPS system, consider a plan π the goal G, and its already executed initial part π_0. π_0 itself is a plan, let $\mathcal{G}_0$ be abducible goals, $G_0 \in \mathcal{G}_0$ its abducted goal and $(P_{\pi_0}, D_{\pi_0}, A_{\pi_0})$ its corresponding operator. Let π_x be the portion of the plan π that has still to be executed, G_x be respect to the initial world model $\mathcal{R}(\pi_0)$) and $(P_{\pi_x}, D_{\pi_x}, A_{\pi_x})$ its corresponding operator. The plan recognition task is that of recognizing π (i.e. π_x) from π_0.

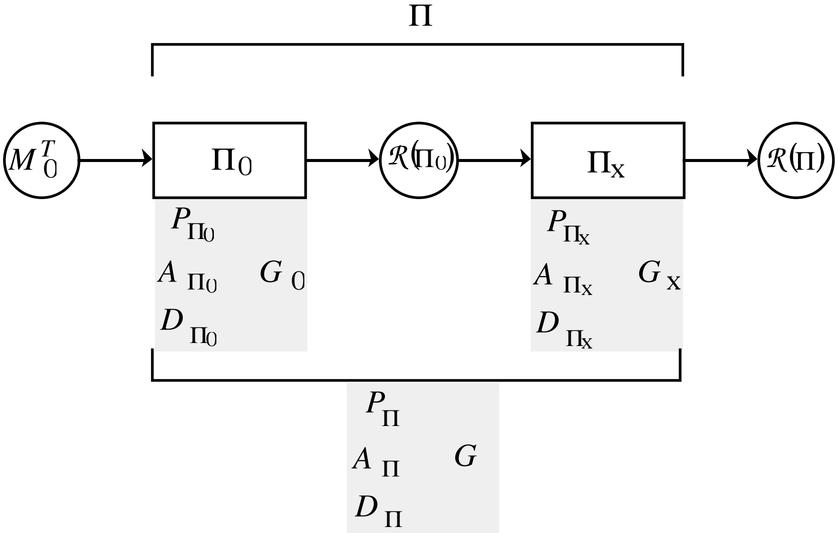

Fig 3. Already executed and still unknown portions of a STRIPS plan.

It can be argued that $G_0 \neq G$ otherwise the rest of the plan π_x would be a waste o other hand G_0 must be someway related to G otherwise π_0 itself would have be time. It may be that:

-$G_0 \subset G$, and/or

-$G_0 = P_{\pi_x}$.

If it is only that $G_0 \subset G$ then π_0 and π_x are two independent subplans. May be th have been performed in parallel or even in the sequence π_x, π_0. However it w difficult for an observer to expect π_x after π_0. The interesting case is that $G_0=P$ out a set of (composite) operators as candidates for π_x. This set can be reduced the overall recognized plan π must be *sensible*. By "sensible" I mean that there mu one reason for the plan to be performed: that is the a

- $m^T{}_0 \cup D_\Pi \nvdash G$
- $m^T{}_0 \cup \neg G \vdash \neg A_\Pi$

must have at least one solution $G \notin \mathcal{G}_0$.

The reduced set can be sorted by domain independent criteria (for instance, t plan) or domain dependent criteria (for instance, the feasibility of the plan or it:

Example 2. Consider the propositional STRIPS system of the previous exampl following operators:

α: **assembly_layer**
P_α: filled_table
D_α: ontable_b1, ontable_b2, ontable_b3
A_α: ontable_layer, handempty

If the blocks cover all the table then the rol assemblies them in a layer.

α: **assembly_tower**
P_α: ontable_b1, on_b2_b1, on_b3_b2
D_α: ontable_b1, on_b2_b1, on_b3_b2
A_α: ontable_tower, handempty

If the block b3 is on b2, b2 is on b1 and b1 is on the table then the robot assemblies them i tower.

α: **puton**_b3_b1
P_α: holding_b3, clear_b1
D_α: holding_b3, clear_b1
A_α: on_b3_b1, clear_b3, handempty

α: **puton**_b2_b1
P_α: holding_b2, clear_b1
D_α: holding_b2, clear_b1
A_α: on_b2_b1, clear_b2, handempty

α: **puton**_b3_b2
P_α: holding_b3, clear_b2
D_α: holding_b3, clear_b2
A_α: on_b3_b2, clear_b3, handempty

α: **puton**_b2_b3
P_α: holding_b2, clear_b3
D_α: holding_b2, clear_b3
A_α: on_b2_b3 clear_b2, handempty

α: **pickup**_b2
P_α: handempty, clear_b2
D_α: handempty, clear_b2
A_α: holding_b2

α: **pickup**_b3
P_α: handempty, clear_b3
D_α: handempty, clear_b3
A_α: holding_b3

Let π_0 be the single-action plan **putdown**_b1. Here are three possible π_x:

$\pi 1=\pi_0$, $\pi_x 1=$ (**putdown**_b1,) **assembly_layer**
$P_{\pi_x 1}$: filled_table
$D_{\pi_x 1}$: ontable_b1, ontable_b2, ontable_b3
$A_{\pi_x 1}$: ontable_layer, handempty

$\pi 2=\pi_0$, $\pi_x 2=$ (**putdown**_b1,) **pickup**_b2, **puton**_b2_b1, **pickup**_b3, **puton**_b3_b2, **assembly_tower**
$P_{\pi_x 2}$: handempty, clear_b2, clear_b1, clear_b3, ontable_b1
$D_{\pi_x 2}$: ontable_b1, on_b2_b1, on_b3_b2, holding_b3, clear_b2, holding_b2, clear_b1
$A_{\pi_x 2}$: ontable_tower, clear_b3, handempty

$\pi 3=\pi_0$, $\pi_x 3=$ (**putdown**_b1,) **pickup**_b3, **puton**_b3_b1, **pickup**_b2, **puton**_b2_b3
$P_{\pi_x 3}$: handempty, clear_b3, clear_b1, clear_b2
$D_{\pi_x 3}$: holding_b2, clear_b3, holding_b3, clear_b1
$A_{\pi_x 3}$: on_b2_b3 clear_b2, handempty, on_b3_b1

Each left subplan is itself a possible π_x. Consider the preconditions of thes operators, $P_{\pi_x 1}$, $P_{\pi_x 2}$ and $P_{\pi_x 3}$. If we limit the goal definition to any conjunctic verified in $M^T{}_i$ but not in $M^T{}_{i-1}$, then only $P_{\pi_x 1}$ can be considered as possible g should be noted that this result would not be achieved without abduction. If w definition to encomprise in the conjunction the negation of literal(s) verified bc

M^{T}_{i-1}, then even $P_{\Pi x2}$ and $P_{\Pi x3}$ are considerable as possible goals. However we
rather than π_3 because the preceding plan π_0 led the world to a more specialize
ontable_b1 is verified. It should be noted that $\vdash P_{\Pi x2}, P_{\Pi x3}$, that is $\neg P_{\Pi x2} \vdash \neg P_{\Pi x3}$, i.e. $\Phi_3 = \neg P_{\Pi x3}$ is (strongly) less presumptive than $\Phi_2 = \neg P_{\Pi x2}$. Various examples of this kind sugg presumption, while not sufficient to discriminate possible goals, is bette presumption.

6. CONCLUSIONS

If a STRIPS-like planner possesses sufficient inferential abilities, then the goa can be generalized to be some "logical consequence(s)" of the changes made in t plan. I've shown that, in such a case, under the hypothesis that the planner complete, goal recognition can be regarded as a clause-based abduction proble clause to explain making a single clause as hypothesis. Furthermore, I've given s sort the abducible goals according to their plausibility and I show how goal rec regarded as a step in plan recognition. However, STRIPS is a very simple pl recognition can be characterized by many other features for hierarchical, para conditional and temporal planners!

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