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DIV: B/B1

AI

Exp8

Aim: A Study on Planning Problem in AI.

Theory:

Artificial Intelligence is a critical technology in the future. Whether it is intelligent robots or self-driving cars or smart cities, they will all use different aspects of Artificial Intelligence!!! But to create any such AI project, **Planning** is very important. So much so that Planning is a critical part of Artificial Intelligence which deals with the actions and domains of a particular problem. Planning is considered as the reasoning side of acting.
Everything we humans do is with a certain goal in mind and all our actions are oriented towards achieving our goal. In a similar fashion, planning is also done for Artificial Intelligence. For example, reaching a particular destination requires planning. Finding the best route is not the only requirement in planning, but the actions to be done at a particular time and why they are done is also very important. That is why planning is considered as the reasoning side of acting. In other words, planning is all about deciding the actions to be performed by the Artificial Intelligence system and the functioning of the system on its own in domain independent situations.

For any planning system, we need the domain description, action specification, and goal description. A plan is assumed to be a sequence of actions and each action has its own set of preconditions to be satisfied before performing the action and also some effects which can be positive or negative.

So, we have Forward State Space Planning (FSSP) and Backward State Space Planning (BSSP) at the basic level.

Forward State Space Planning (FSSP)

FSSP behaves in a similar fashion like forward state space search. It says that given a start state S in any domain, we perform certain actions required and acquire a new state S' (which includes some new conditions as well) which is called progress and this proceeds until we reach the goal state. The actions have to be applicable in this case. Disadvantage: Large branching factor

Advantage: Algorithm is Sound

Backward State Space Planning (BSSP)

BSSP behaves in a similar fashion like backward state space search. In this, we move from the goal state g towards sub-goal g' that is finding the previous action to be done to achieve that respective goal. This process is called regression (moving back to the previous goal or sub-goal). These sub-goals have to be checked for consistency as well. The actions have to be relevant in this case.

Disadvantage: Not a sound algorithm (sometimes inconsistency can be found)

Advantage: Small branching factor (very small compared to FSSP)

Example:

Planning in artificial intelligence is about decision-making actions performed by robots or computer programs to achieve a specific goal.

Execution of the plan is about choosing a sequence of tasks with a high probability of accomplishing a specific task.

Block-world planning problem

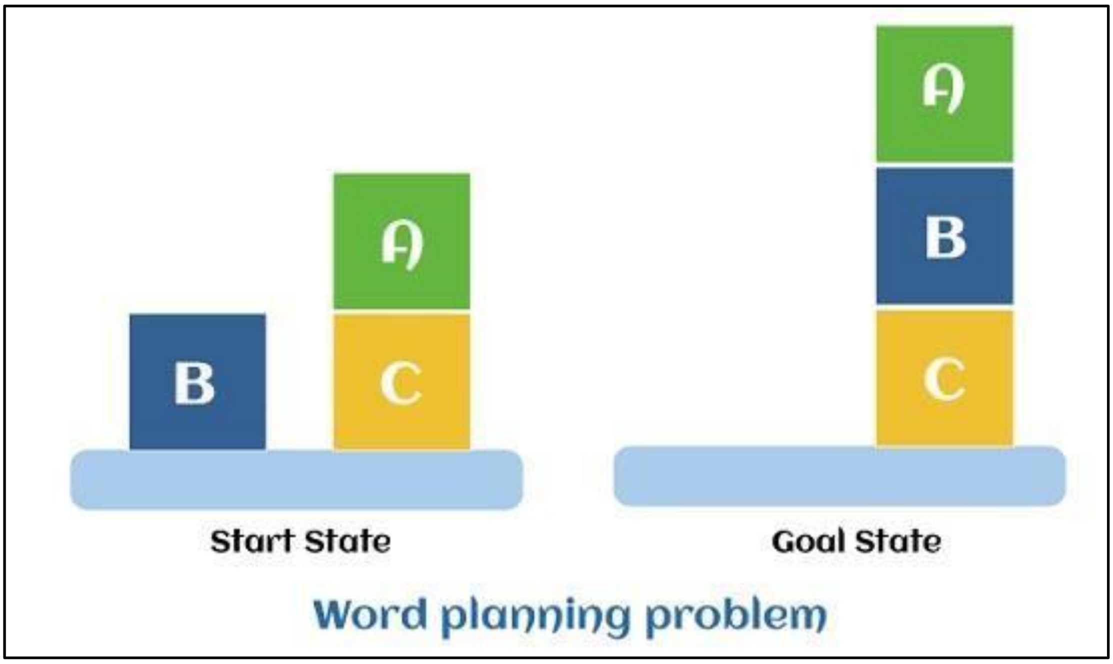
The block-world problem is known as the Sussmann anomaly.

The non-interlaced planners of the early 1970s were unable to solve this problem. Therefore it is considered odd.

When two sub-goals, G1 and G2, are given, a non-interleaved planner either produces a plan for G1 that is combined with a plan for G2 or vice versa.

In the block-world problem, three blocks labeled 'A', 'B', and 'C' are allowed to rest on a flat surface. The given condition is that only one block can be moved at a time to achieve the target.

The start position and target position are shown in the following diagram.



Components of the planning system

The plan includes the following important steps:

Choose the best rule to apply the next rule based on the best available guess. o Apply the chosen rule to calculate the new problem condition.

Find out when a solution has been found. o Detect dead ends so they can be discarded and direct system effort in more useful directions.

Find out when a near-perfect solution is found.

Target stack plan o It is one of the most important planning algorithms used by STRIPS. o Stacks are used in algorithms to capture the action and complete the target. A knowledge base is used to hold the current situation and actions.

A target stack is similar to a node in a search tree, where branches are created with a choice of action.

The important steps of the algorithm are mentioned below:

Start by pushing the original target onto the stack. Repeat this until the pile is empty. If the stack top is a mixed target, push its unsatisfied sub-targets onto the stack.

If the stack top is a single unsatisfied target, replace it with action and push the action precondition to the stack to satisfy the condition.

iii. If the stack top is an action, pop it off the stack, execute it and replace the knowledge base with the action's effect.

If the stack top is a satisfactory target, pop it off the stack.

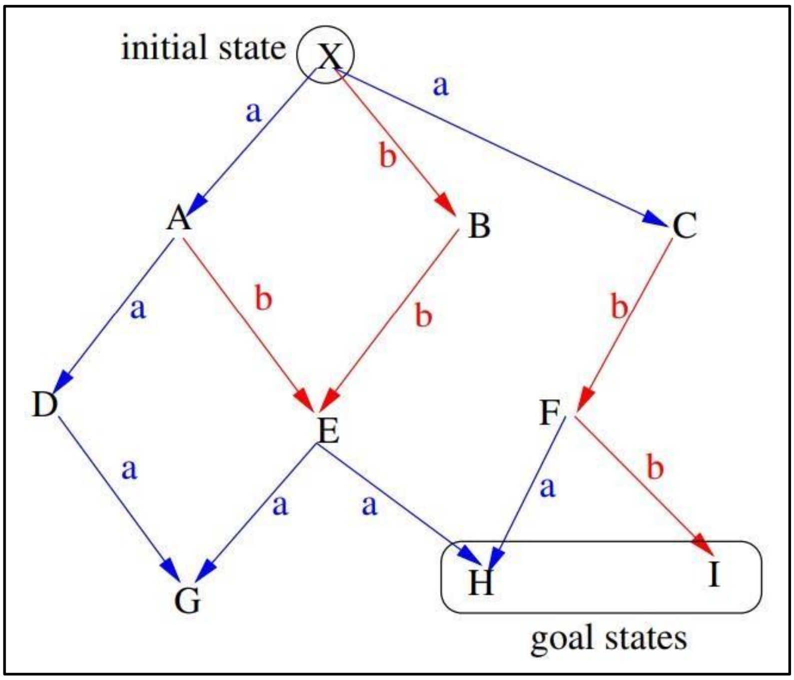
➢ Planning Through State Space Search

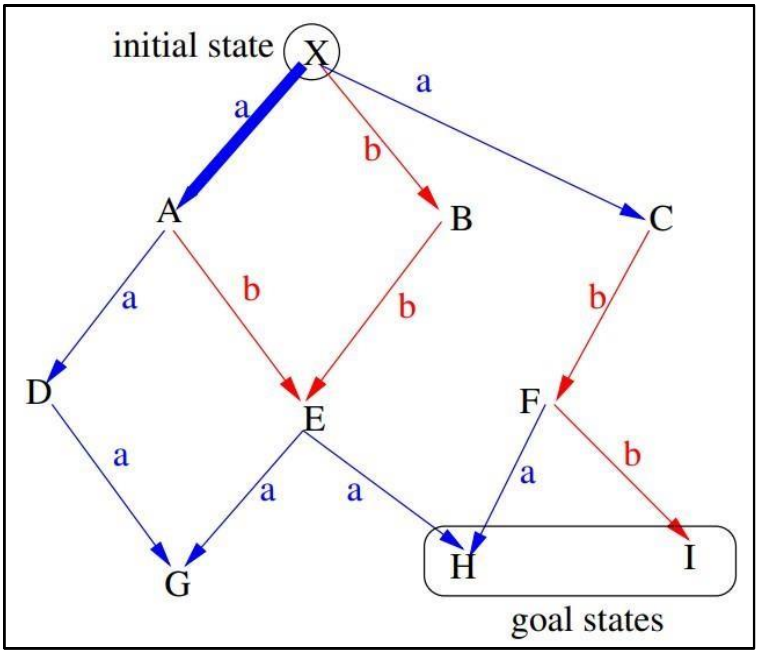
We can view planning problems as searching for goal nodes in a large labeled graph (transition system)

Nodes are defined by the value assignment to the fluents = states

Labeled edges are defined by actions that change the appropriate fluents

Use graph search techniques to find a (shortest) path in this graph! Note: The graph can become huge: 50 Boolean variables lead to 250 = 1015 states   Create the transition system on the fly and visit only the parts that are necessary


initial state
X
a
b
a
A
B
C
a
b
b
b
D
E
F
a
a
a
a
b
H
I
G
goal states


initial state
X
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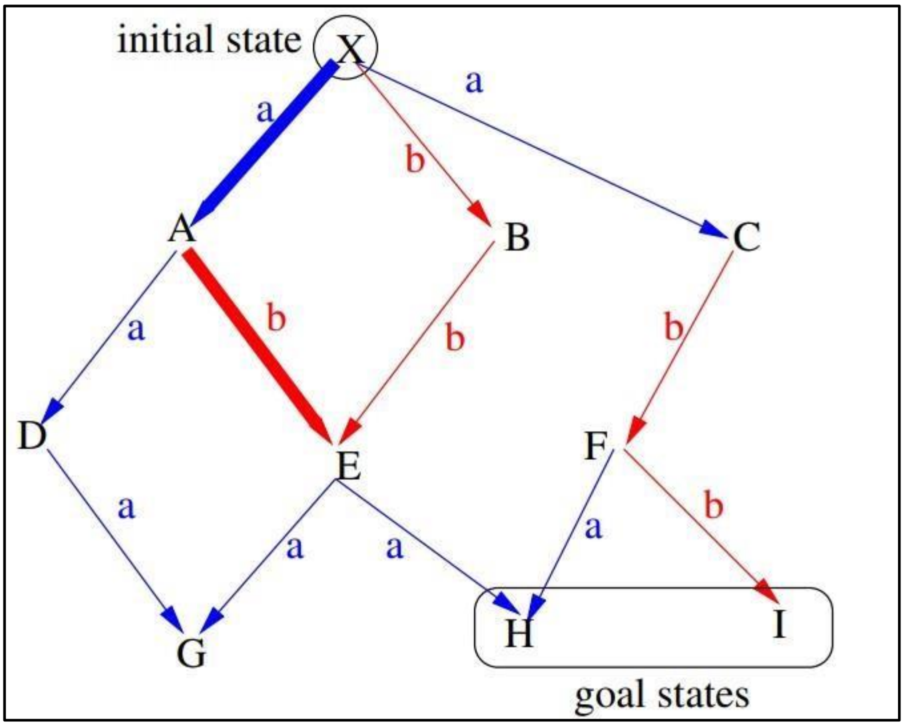
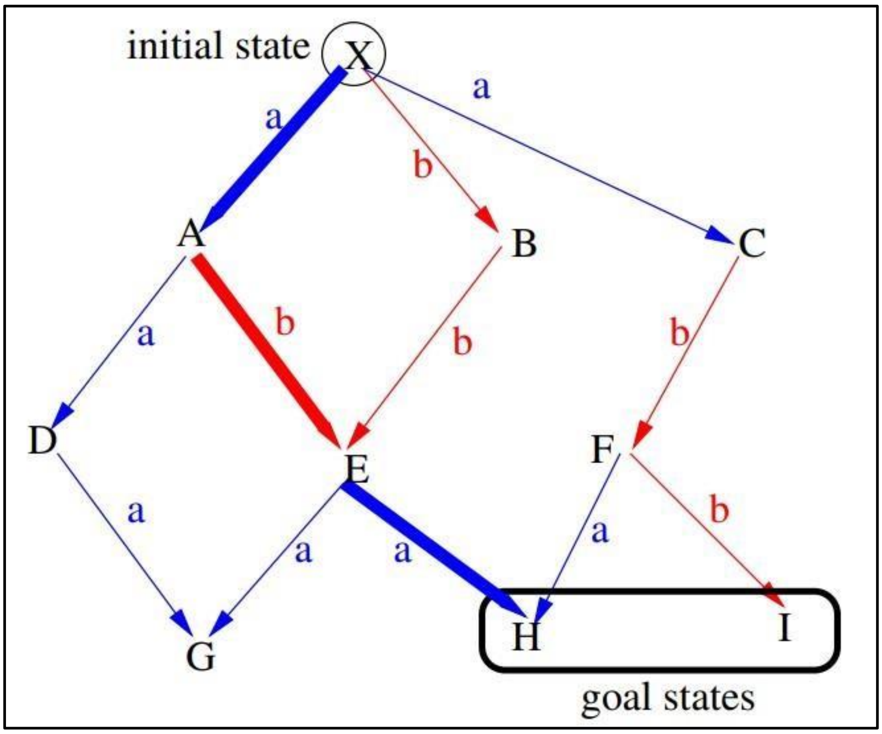
goal states





Let’s Consider a planning problem and try to solve it with Forward state space search planning and Backward state space search planning.

Forward state space search planning

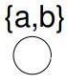
Search through transition system starting at initial state

1. Initialize partial plan $\Delta := \langle \, \rangle$ and start at the unique initial state $\mathbf{I}$ and make it the current state S
2. Test whether we have reached a goal state already: $\mathbf{G} \subseteq S$? If so, return plan Δ.
3. Select one applicable action o_i non-deterministically and
   - compute successor state $S := App(S, o_i)$,
   - extend plan $\Delta := \langle \Delta, o_i \rangle$, and continue with step 2.

Instead of non-deterministic choice use some search strategy.
Progression planning can be easily extended to more expressive planning languages

Problem:

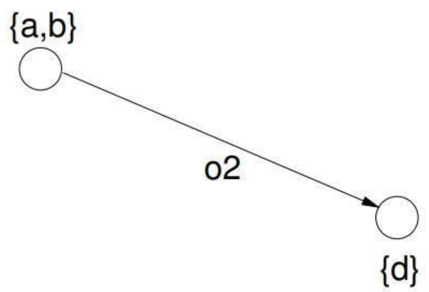
$$
\begin{aligned}
\mathcal{S} &= \{a, b, c, d\}, \\
\mathbf{O} &= \{\; o_1 = \langle \emptyset, \{a, b\}, \{\neg b, c\} \rangle, \\
&\qquad o_2 = \langle \emptyset, \{a, b\}, \{\neg a, \neg b, d\} \rangle, \\
&\qquad o_3 = \langle \emptyset, \{c\}, \{b, d\} \rangle, \\
\mathbf{I} &= \{a, b\} \\
\mathbf{G} &= \{b, d\}
\end{aligned}
$$



Solution:

Backward state space search planning Problem:

$$\begin{aligned}\mathcal{S} &= \{a,b,c,d\},\\ \mathbf{O} &= \{\ o_1 = \langle \emptyset, \{a,b\}, \{\neg b, c\}\rangle,\\ &\quad\ \ o_2 = \langle \emptyset, \{a,b\}, \{\neg a, \neg b, d\}\rangle,\\ &\quad\ \ o_3 = \langle \emptyset, \{c\}, \{b,d\}\rangle,\\ \mathbf{I} &= \{a,b\}\\ \mathbf{G} &= \{b,d\}\end{aligned}$$



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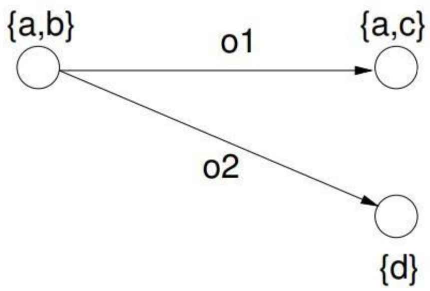

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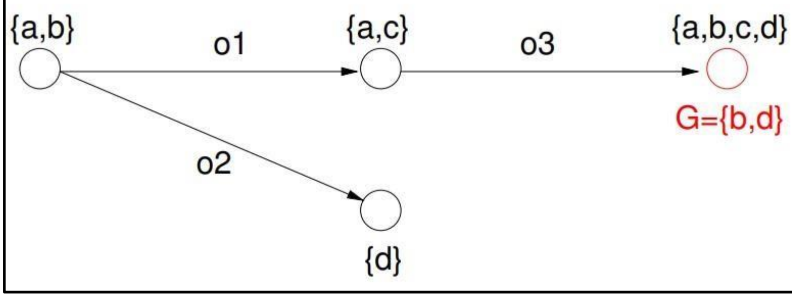


Search through transition system starting at goal states. Consider sets of states, which are described by the atoms that are necessarily true in them

1. Initialize partial plan $\Delta := \langle\,\rangle$ and set $\mathbf{S} := \mathbf{G}$
2. Test whether we have reached the unique initial state already: $\mathbf{I} \supseteq \mathbf{S}$? If so, return plan Δ.
3. Select one action o_i non-deterministically which does not make (sub-)goals false ($\mathbf{S} \cap \neg \mathit{eff}^-(o_i) = \emptyset$) and
   - compute the regression of the description $\mathbf{S}$ through o_i:

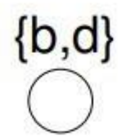
     $$\mathbf{S} := \mathbf{S} - \mathit{eff}^+(o_i) \cup \mathit{pre}(o_i)$$

   - extend plan $\Delta := \langle o_i, \Delta \rangle$, and continue with step 2.

Instead of non-deterministic choice use some search strategy
Regression becomes much more complicated, if e.g. conditional effects are allowed. Then the result of a regression can be a general Boolean formula

Solution:

$$\begin{aligned}
\mathcal{S} &= \{a, b, c, d, e\},\\
\mathbf{O} &= \{\ o_1 = \langle \emptyset, \{b\}, \{\neg b, c\} \rangle,\\
&\qquad o_2 = \langle \emptyset, \{e\}, \{b\} \rangle,\\
&\qquad o_3 = \langle \emptyset, \{c\}, \{b, d, \neg e\} \rangle,\\
\mathbf{I} &= \{a, b\}\\
\mathbf{G} &= \{b, d\}
\end{aligned}$$



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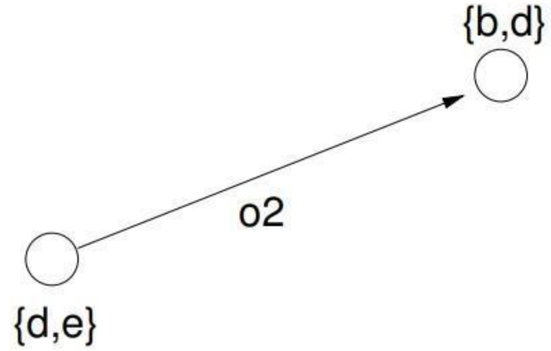

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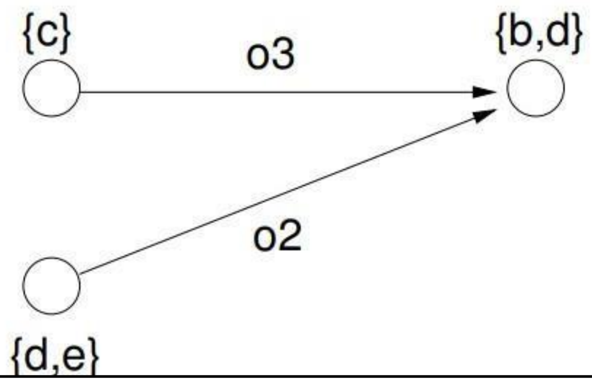

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\end{aligned}
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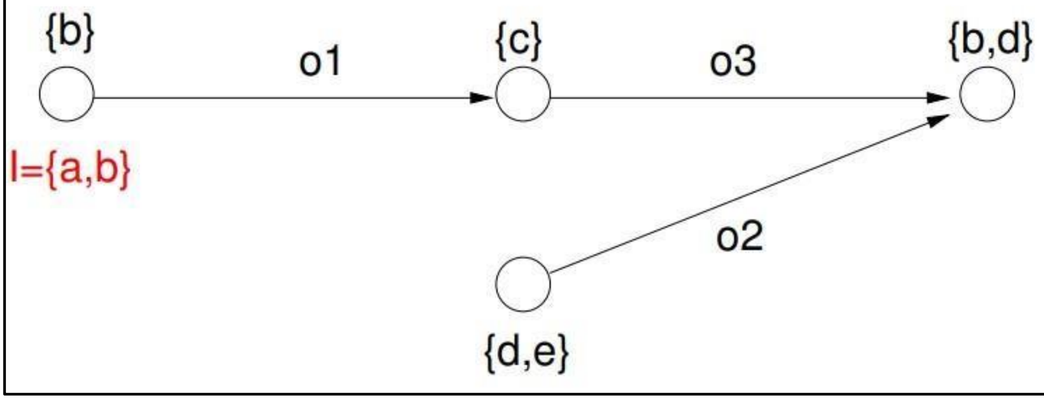

Conclusion: Thus, we have successfully performed study on planning problem.