RESEARCH REVIEW

Historical Developments in AI Planning and Search

Udacity AI Nanodegree

Project 4- Planning

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Introduction – AI Planning and Search

Planning and Search are both subfields of Artificial Intelligence (AI). Together these techniques form the foundation of today's intelligent systems by improving their autonomy and flexibility through the construction of sequences of actions to achieve their goals.

Planning involves the representation of actions and world models, reasoning about the effects of actions, and techniques for efficiently searching the space of possible plans. The end result is a highly efficient plan which guarantees the goal state within acceptable time constraints.

Planning techniques have been applied in a variety of tasks including robotics, process planning, web-based information gathering, autonomous agents and spacecraft mission control.

This paper will highlight three key historical developments in the AI Planning domain and their impact on the field AI.

STRIPS – Stanford Research Institute Problem Solver

In 1971, Richard Fikes and Nils Nilsson at Stanford Research Institute developed a new approach to the application of theorem proving in problem solving. Formally, the problem space for STRIPS is defined by the initial world model, the set of available operators and their effects on world models, and the goal statement. Each operator is defined by a description consisting of two main parts: the effects the operator has and conditions under which the operator is applicable.

Next the problem is defined in terms of an initial state and a goal condition. STRIPS then employs search algorithms to search through the state space to arrive at a goal state. In other words, a problem is said to be solved when STRIPS produces a world model that satisfies the goal statement.

In layman's terms, STRIPS provides a common language to represent problems in classical planning.

PDDL – Planning Domain Definition Language

Developed by Drew McDermott in 1998, PDDL was intended to standardize Artificial Intelligence planning languages. It simplifies the planning tasks by providing code constructs in simple English which can be easily understood.

The below figure shows the Air Cargo Problem expressed in PDDL

```
Init(At(C1, SFO) ∧ At(C2, JFK)
∧ At(P1, SFO) ∧ At(P2, JFK)
∧ Cargo(C1) ∧ Cargo(C2)
∧ Plane(P1) ∧ Plane(P2)
∧ Airport(JFK) ∧ Airport(SFO))
Goal(At(C1, JFK) ∧ At(C2, SFO))
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GraphPlan Algorithm

GraphPlan was developed by Avrium Blum and Merrick Furst at Carnegie Mellon in 1997 to approach planning without relying on greedy search.

Before commencing the actual search, GraphPlan constructs a data structure called Planning Graph consisting of all possible moves using forward search. The Planning Graph inherently encodes useful constraints explicitly, thereby reducing the search overhead in the future. Planning Graphs can be constructed in polynomial time and have polynomial size. On the other hand, the state space search is exponential and is much more work to build. Planning graphs are not only based on domain information, but also the goals and initial conditions of the problem and an explicit notion of time.

This approach minimizes the search time and also avoids searching the entire search space. While GraphPlan borrows ideas from total order and partial order planning, it improves on both of them by defining the planning problem as a graph thereby delivering an efficient solution. GraphPlan also stands apart from other algorithms by providing a termination guarantee, which is extremely important in executing real life domain problems.

References

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