Research Review: AI Planning and Search Developments

Planning is the task of finding a sequence of actions that will achieve a goal. If the planning environment is fully observable, deterministic, finite, static and discrete, it will be called **classical planning**. The core idea in classical planning is based on describing the problem in terms of states and actions and searching for the goal. The search can be simple if the search space is reasonably small but in most of the real world applications the state space grows exponentially and many innovations have been developed during years to solve the planning problems efficiently.

STRIPS was the first major **automated planner** and also the name of the formal language of the inputs to this planner. The STRIPS language describes actions in terms of their preconditions and effects and describes the initial and goal states as conjunctions of positive literals. This language is the base for most of the languages for expressing automated planning problem instances in use today. The ADL language relaxes some of the constraints of the STRIPS, allowing disjunction, negation, and quantifiers. Creation of languages like STRIPS and ADL was and important step because they define a structure to describe and formalize a planning problem which can be used by different search algorithms.

The most natural search strategy is state space search which can be done as forward or backward search known as progression and regression planning. Planners of this type were used in the early 1970s and worked with totally ordered action sequences but they could not take advantage of problem decomposition. Problem decomposition was achieved by computing a sub-plan for each subgoal and then stringing the sub-plans together in some order. This approach, called linear planning was soon discovered to be incomplete. To address these shortcomings, **Partial-order planning** dominated the next 20 years of research. Partial-order planning is an approach that leaves decisions about the ordering of actions as open as possible. Given a problem in which some sequence of actions is required in order to achieve a goal, a partial-order plan specifies all actions that need to be taken, but specifies an ordering of the actions only where necessary. The general strategy of delaying a choice during search is called a least commitment strategy. In addition to the smaller search space for partial-order planning, it may also be advantageous to leave the option about the order of the actions open for later.

The other important achievement was development of **Graphplan**. Graphplan is an algorithm for automated planning which takes as input a planning problem expressed in STRIPS and produces, if one is possible, a sequence of operations for reaching a goal state. The name Graphplan is due to the use of a planning graph, to reduce the amount of search needed to find the solution from exploration of the state space graph. Graphplan was orders of magnitude faster than the partial-order planners of its time.

Another important finding in state space planning was suggesting a distance heuristic based on a **relaxed problem** with delete lists ignored which caused popularity of state space search again.

References:

1- Russel, Stuart and Norvig, Peter: Artificial Intelligence: A modern approach. , 3rd edition
2- https://en.wikipedia.org/wiki/STRIPS
3- https://en.wikipedia.org/wiki/Partial-order_planning
4- https://en.wikipedia.org/wiki/Graphplan