Research review

"Overview of major historical developments in artificial intelligence planning and search"

Udacity Artificial Intelligence Nanodegree – Isolation game
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Context

The concept of *Artificial Intelligence* (AI) refers to the features showed by machine that mimic human intelligence. It embeds different concepts like reasoning, knowledge representation, learning, natural language processing, perception, robotics, social intelligence, creativity and general intelligence [1]. It appears that AI tends to describe "whatever hasn't been done yet" [2], and by contrast it is not used anymore to describe the behavior of machines once the algorithm is found [2].

Planning and Search represents one specific discipline of AI that makes use of intelligent agents to discover optimal chain of actions to achieve a given goal, while being able to adapt to changing and potentially unknown environment.

Key development 1: *Representational Language*
Driven by the needs of robotics, the planning system STRIPS [3,4] developed in the 1970s and its representational language opened the path to the description languages like ADL (Action Description Language) and PDDL (Problem Domain Description Language) [5] that are still the reference today. PDDL represents a standard formalism to describe AI problems [8], in particular to describe *states, actions* and *goals* of a problem.

Key development 2: *Partial-Ordered Planning*
Instead of searching a solution to a goal in the full search space containing all possible orders of actions as in *Totally Ordered Planning*, advantage can be taken decomposing the problem in subproblems with related subgoals. In this context, *Partial-Order Planning* specifies only the order of actions needed, while keeping track of all possible actions [6] and ensuring the detection of conflicts between subgoals and conditions [7]. Emerging in the 1970s, this algorithm dominated the 20 years of research while still being improved with better heuristics until the 2000s [5].

Key development 3: *Planning Graph*
As an alternative to state-space search, solutions to the problem can be searched on so-called *Planning Graphs*, that consist of a succession of levels of *states* S_n and *actions* A_n, namely the possible *effects* (S_{n+1}) resulting of possible *actions* (A_n) applicable on given *preconditions* (S_n). In addition, the graph contains constraints saying which states or actions are mutually exclusive. The graph obtained is polynomial and can be used to provide an efficient estimation of the cost to the search algorithm (like A*). The GRAPHPLAN algorithm uses the planning graph to extract a plan of the actual problem by iteratively adding a level and checking that all goals are non mutually exclusive, in which case it extracts the solution or add another level if it's not the case. Additional variants make use of planning graphs to directly extract a solution to the problem.

References

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