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This report describes at least three key historical developments in the field of AI planning and the relationships between them. Automated planning techniques generate a plan (workflow) automatically by computing a sequence of actions which will transition a system from some initial state to some required goal state. Each action has preconditions which are constraints that have to be satisfied before executing the action, and effects which are conditions that will be true after executing the action.

According to the Russell-Norvig text (Russell & Norvig, 2010), the most popular and effective approaches to automated planning are (1) Boolean satisfiability, (2) forward search with good heuristics, and (3) search using a planning graph.

Boolean satisfiability

Boolean satisfiability is the idea of finding a plan through a logic equation using propositional logic of all the axioms that are inferred by the initial state, goals, and possible actions for a given problem. One of the key historical developments along the way to this methodology is the work of the mathematician Ernst Schröder (Schröder, 1877).

State-space planning: Forward search with heuristics

Perhaps the best known modern heuristic search algorithm is A-star, which combines path cost with a heuristic to choose its search expansion nodes during a planning search. A planning search is a search where the nodes of the graph are states and the edges (paths) of the graph are the actions that are valid between states.

By providing a heuristic that estimates the true distance to goal from any given node, the A-star algorithm is able to choose actions that move closer and closer to the goal. It is optimal, and its efficiency is dependent on the quality and efficiency of the heuristic itself. Other search algorithms that used heuristics had been studied prior to A-star, but A-star takes path cost into account. This was presented by Hart et al in 1968 (Hart, Nilsson, & Raphael, 1968).

Planning-Graph

A planning graph uses a graph structure where nodes correspond to world state propositions and actions, and arcs correspond to preconditions and effects of actions. The algorithms expand the graph from the initial state until reaching the last layer that contains all goals which must not be mutually exclusive. The solution (plan) can be found by applying a backward-search algorithm from the last until reaching the first proposition layer.

The planning graph can be used to provide automated admissible heuristics for any domain. The planning graph can be used to calculate heuristics such as “level-sum” for use with more traditional searches. Alternatively, it may be used directly to solve the planning problem with the Graphplan algorithm (Blum & Furst, 1997).

Russell, S., & Norvig, P. (2010). Artificial Intelligence: a modern approach.
Herry Herry & Paul Anderson & Gerhard Wickler(2010). Automated Planning for Configuration Changes.
Avrim L. Blum & Merrick L. Furst(1997). Fast Planning Through Planning Graph Analysis.