AI Planning Research Review

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In 1971, Fikes and Nilsson of the Stanford Research Institute described a general problem-solving agent. By modeling a problem space as an arbitrary collection of first-order predicate calculus formulas, and uses these formulas to transform a given problem state into a goal state.

STRIPS (Stanford Research Institute Problem Solver) was designed to provide action steps to a robot to reach an action state. Similar systems had been designed for solving problems in games and puzzles, but the systems designed for these purposes were insufficient for accounting for the large number of facts and relations involved in designing solutions for problems in a world model.

A world model, as described by STRIPS, consists of a set of well-formed formulas in first-order predicate calculus defining the current state of the system. A set of parameterized operators are defined which can be applied to a model to generate a new model. Finally, a goal state is defined as a well-formed formula.

Because the search tree generated by a complex collection of formulas (with different parameters increasing the complexity), a smarter method of searching the possibilities was required. The GPS strategy involves extracting the differences between the current state and the goal state and only analyzes the operators which are relevant to reducing these differences.

According to Russell and Norvig in their text, Artificial Intelligence: A Modern Approach, one shortcoming of approaches to planning thus far is a lack of planners with the ability to handle interleaving of actions from different subplans within a single sequence. This was resolved by the introduction of goal-regression planning, which searched the world space from the goal node to the start node, rather than start-to-goal.

In 1987, Chapman introduced the TWEAK algorithm which expanded on the findings of Fikes, Nillson and others by introducing solutions for conjuctive problem-solving – achieving multiple goals at the same time. This solution came about by means of searching for solutions nonlinearly, meaning not from start-to-finish or vice versa but in pieces and chunks along the way.

TWEAK consists of a plan representation, a method of forming a plan to achieve a goal, and a top-level control structure. The plan representation layer determines whether a particular proposition will be true of the world after part of a plan has been executed. The problem-solving procedure is nondeterministic, and can be backtracked via the top-level control structure if a wrong decision is made along the way.

The1987 paper by Chapman specifically outlines a flaw with itself and former planning systems- the representation of actions in terms of First-order logic does not allow for indirect effects or for the effects of an action to depend on the situation in which it is applied. This is known as the frame problem.

For this, Raymond Reiter (1991) introduced a solution for solving this problem when all side effects and situational secondary effects can be enumerated to be used in regressive analysis introduced by Waldinger (1974).

STRIPS: A New Approach to the Application of Theorem Proving to Problem Solving Nikes,

Fillson 1971

Artificial Intelligence: A Modern Approach Russell, Norvig 2010

Planning For Conjuctive Goals, David Chapman 1987

The Frame Problem in the Situation Calculus: A Simple Solution (Sometimes) and a Completeness Result for Goal Regression Raymond Reiter 1991