Research Review: a summary of at least three key developments in the field of AI planning and search.

1. STRIPS (1971, Stanford)

In solving problems like puzzles and games, data structures like simple matrix and list are usually adequate representations. However, when it comes to navigation and object rearrangement in robot, the world model is much more complex including large number of facts and relations. To solve planning problem in this more complex situation, Richard Fikes and Nils Nilsson at Stanford developed STRIPS (STanford Research Institute Problem Solver).

STRIPS is a problem solving system that applied theorem-proving approach to search a space of "world models". The problem space for STRIPS is defined by 3 entities: an initial world model, a set of operators and a goal condition. The system searches for composition of operators, which transforms the world model into one that satisfies goal condition. To find a relevant operator, it will first produce an applicable world model and then reconsider the original goal.

A characteristic property of STRIPS is that theorem-proving methods are only used to answer whether operations are applicable or goals are satisfied, while searching method implemented a GPS-like means-end analysis to find goal-satisfying model. As an improved version from previous problem-solving system by Green, STRIPS overcame the "frame problem" by separating processes of theorem proving from searches through space of world models.

2. Graphplan (1997, CMU)

Avrim Blum and Merrick Furst at CMU first develop Graphplan, which is a new approach to planning in STRIPS-like domains based on graph algorithms. Graphplan outperformed existent total-order planner Prodigy and partial-order planner UCPOP in many situations.

Planning graph, unlike state-space graph in which a plan is a path through the graph, is a compact structure in which a plan is a flow of truth-values in the network. Operators in STRIPS-like domains of Planning graph have preconditions, add effects and delete effects and actions, which are fully-instantiated operators at specified times, forming a valid plan in together with no-ops (do nothing/propositions). Planning graph is similar to valid plan, but allows interference of actions at a given step and is guaranteed to return shortest possible partial-order plan or no valid plan exists.

3. SATPLAN (1992, AT&T Bell lab)

Satplan (Planning as Satisfiability) is a method for automated planning. It converts the planning problem instance into an instance of the Boolean satisfiability problem

(while traditionally formalized as deduction), which is then solved using a method for establishing satisfiability such as the DPLL algorithm or WalkSAT. The DPLL algorithm is a complete, backtracking-based search algorithm for deciding the satisfiability of propositional logic formulae in conjunctive normal form. The WalkSAT is a local search algorithm used to solve Boolean satisfiability problems. It works on formulae in Boolean logic that are in, or have been converted into, conjunctive normal form. They start by assigning a random value to each variable in the formula. If the assignment satisfies all clauses, the algorithm terminates, returning the assignment. Otherwise, a variable is flipped and the above is then repeated until all the clauses are satisfied.

Reference:

- A. Blum and M. Furst (1997). **Fast planning through planning graph analysis**. Artificial intelligence. 90:281-300.
- Richard E. Fikes, Nils J. Nilsson (Winter 1971**). STRIPS: A New Approach to the Application of Theorem Proving to Problem Solving.** Artificial intelligence. 2(3-4): 189-208.
- Kautz H A, Selman B. Planning as Satisfiability ECAI. 1992, 92: 359-363