

## Research Review

In 1971, Fikes and Nilsson published the first major planning system STRIPS (Fikes & Nilsson, 1971) in AI history. They defined it as "... a member of the class of problem solvers that search a space of 'world models' to find one in which a given goal is achieved". This program used sets "of well-formed formulas of the first-order predicate calculus" as a representation of world models where it applies various operators to reach goal state. One distinction made by STRIPS was that in STRIPS, the process of theorem proving was separated from the process of searching through the state space. This feature enabled the program to have a more complex world models and also yield effective search heuristics compared to previous methods. This appearance of STRIPS, especially its way of representing world model, had a great influence on future planners and also corresponding languages.

Then, in 1975, Sacerdoti proposed that non-linearity was the nature of planning (Sacerdoti, 1975) when most planners at the time applied linear programming and treat planning as a linear combination of actions.

Sacerdoti demonstrated that linear programming can be non-effective due to its "premature commitments to a particular order of solving sub-goals". Sussman Anomaly was an elegant example describing this defect of linear approaches. Sacerdoti then in this paper formulated a new model of solving planning problems called NOAH which was defined as "a problem-solving and execution monitoring system that uses a linear representation of plans". This was a very first attempts of task networks and it improved the ability of planners by using a complex model (instead of a linear model) to describe the problem.

Since then till 1990s, the main attention of academia was on task networks and tried to improve planner systems' power through a better scheme in the task networks. However, Blum and Furst described a new planner "Graphplan" (Blum & Furst, 1995, 1997) which achieved a faster processing compared to both total-order processor "Prodigy" and the partial-order processor "UCPOP". "Graphplan" provides a new perspective of approaching planning problems by creating a new structure called planning graph. This structure was a polynomial approximation of real state space and had polynomial size which recorded "not only domain information but also the goals and initial conditions of a problem and an explicit notion of time." By conducting analysis on this structure, "Graphplan" was able to "find the shortest plan among those in which independent actions may take place at the same time". However, like all previous developments, "Graphplan"

had its disadvantage: it can only be applied to STRIPS-like domains while STRIPS planning was often of great complexity.

These three developments are only a glance at the history of solving plan and search problems. As an important part of AI in general, planning and searching have significant influences on problem solving and provide necessary abilities for agents to do their desired tasks. Without these developments, AI would lose its model of connecting conditions of the world to goals of the agents.

## Reference

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