Research Review: Historical progress on AI Planning

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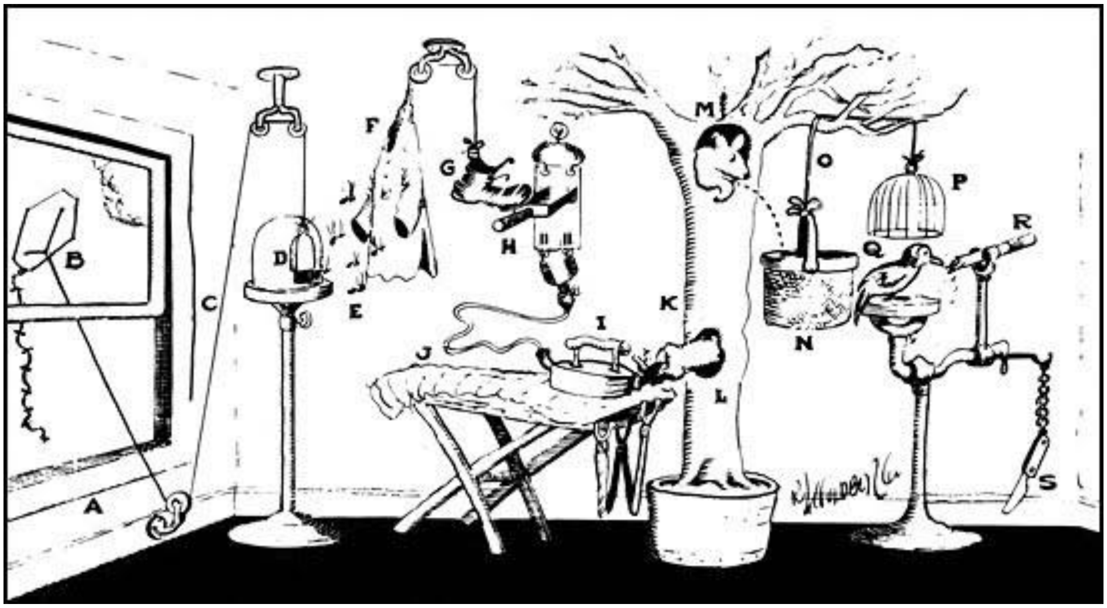

Fig1: AI Planning and Decision Making (Courtesy CS-397 UIUC)

Introduction:

Artificial Intelligence has significant impact on planning from the very beginning of AI application. This development took place gradually over the years based on the progress of technology and demand of the time. Here I discuss three important historical development took place in last 50 years on AI Planning.

Historical Research Progress on AI Planning:

AI planning research developed from inquiries of state-space search, theorem proving, and control theory and from the applied needs of robotics, scheduling, distribution etc.

Fikes and Nilsson described a problem solver for planning called STRIPS (Stanford Research Institute Problem Solver) in 1971[1], the first major planning system, illustrated a sequence of operators in a space of world models to transform an initial world model in which a given goal formula can be proven to be true. STRIPS was designed as the planning component of the software for the Shakey robot project at SRI. STRIPS represented in a first-order predicate calculus formula. It employed a resolution theorem prover to answer questions of a model and used means-ends analysis to guide to the desired goal-satisfying model. The representation language used by STRIPS has been more influential than its algorithmic approach. Its overall control structure was modeled based on the General Problem Solver (GPS). These approaches, called linear planning which totally ordered action sequences.

Linear planning could not solve many problems. A complete planner must allow for inter leaving of actions from different subplans within a single sequence. Several researches carried out in 70-80's. Then Partial-order planning dominated the next 20 years of research. The first clear formal exposition was TWEAK [4], a planner that was simple enough to allow proofs of completeness and intractability of various planning problems, it could solve any nonlinear planning problem. It defined a plan by incrementally specifying partial constraints to fit. The search space was pruned as constraints were added, until all remaining alternatives satisfied the constraints minimizing backtracking.

The heart of TWEAK was a polynomial-time algorithm that computed possible and necessary properties of an incomplete plan. The top-level loop of the planner non-deterministically choosed a goal that was not already achieved and used a procedure which made the plan achieve that goal.

This is how from linear incomplete planning, adding the interleaving problem to improve it. Then partial-order planning made clearer with proofs of completeness using tweak planner.

In recent years use of appropriate heuristic search showed lots of success. Jiang, Z., & Hirokawa, S. in their paper "Dynamic macro-based heuristic planning through action relationship analysis" [3] talked about automatically improving the design of heuristic search function by analyzing the action relationship of a solved problem in the same domain. Rather than focusing on domain-independent planning, this approach sets out to use the domain knowledge to improve the planner performance.

The relationships among actions were studied and proposed an algorithm that generated macros from solved cases. Then a dynamic heuristic reusing the generated macros integrated it into a working planning system called the Dynamic Macro-based Fast Forward or DM-FF system. They evaluated their method in a series of experiments with improved performance.

Conclusion:

Like any other field of study planning will keep on evolving. The development will follow the key principle "Necessity is the mother of all invention". With the flood of modern technology and rapid development of AI, there will be new challenges. AI Planning will need to catch up the demand of the time and situation.

Bibliography:

[1] Fikes, R. E. and Nilsson, N. J. (1971). STRIPS: A new approach to the application of theorem proving to problem solving. AIJ, 2(3–4), 189–208.

[2] Chapman, D. (1987). Planning for conjunctive goals. AIJ, 32(3), 333–377.

[3] Jiang, Z., Wen, J., Zeng, J., Zhang, Y., Wang, X., & Hirokawa, S. (2015). Dynamic macro-based heuristic planning through action relationship analysis. IEICE Transactions on Information and Systems, E98D(2), 363-371.