Brief History Of Planning Problems in Artificial Intelligence

This short paper is intended to give a brief overview of how approaches to planning problems has evolved during the last 50 years, touching on the three developments that have had the largest impacts.

The first major development occurred in 1971 with the development of the STRIPS[1] planning system (STanford Research Institute Problem Solver). This paper was published by Fikes and Nilson of Stanford Research Institute. This paper formalized the use of propositional logic for planning problems. STRIPS represented the world with a set of "well formed formulas", much like what was used in the air cargo planning problem during the AIND Nanodegree class as a propositional logic statement. For example, box B might be at location b in a world, while box C might be at location c. This would be represented as "At(B, b)" and "At(C, c)" while the following negation relations "~At(B, c)" and "~At(C, b)" would also hold (since a box cannot be in two places at the same time). STRIPS also represented the goal states with the same well formed formulas, and managed transitions between the states using "actions" which produced effects on the world (by updating the well formed formula) and also attaching pre-conditions to the actions, such that an action can only be executed if its preconditions are satisfied.

The advent of STRIPS was the first planning system to formulate planning problems in terms of propositional logic representing world states and goals, and actions which produced effects on the world states. The next major advancement in the field was achieved in 1997 with an algorithm called GRAPHPLAN[2], published by Blum and First of Carnegie Mellon University. This paper introduced the concept of "Planning Graph Analysis". The key insight in this work is to represent the world as a leveled graph composed of two kinds of level: propositional levels containing propositional nodes describing the state of objects in the world, and action levels containing action nodes (connected to preconditions and consequences, represented by propositional nodes). The levels would alternate as propositional - action - propositional - action and so on. In this way the planning graph encoded the problem concisely without encoding the entire state space. As a result searching the planning graph was very efficient.

The next advancement appears in the form of a domain independent planner called HSP[3] (Heuristic Search Planner) and a related algorithm FF[4] (Fast Forward Planner). Both systems approach the planning problem using heuristic search, using the assumption that if the subgoals are independent then solving a relaxed version of the problem is an admissible estimate of the

[1] STRIPS paper: http://ai.stanford.edu/~nilsson/OnlinePubs-Nils/PublishedPapers/strips.pdf
[2] GRAPHPLAN paper: https://www.cs.cmu.edu/~avrim/Papers/graphplan.pdf
[3] https://bonetblai.github.io/reports/aips98-competition.pdf
[4] https://pdfs.semanticscholar.org/ae6f/11cfd1523e6fcf1f7857971cc92ce526cd12.pdf

complexity of the true problem. Heuristics are extracted from the STRIPS-type planning problem, and the problem is then typically relaxed by often assuming that action preconditions are independent. The FF algorithm operates in the same manner as the HSP algorithm, but has been shown to outperform HSP on some large domain planning problems, indicating a more efficient implementation than HSP.

I hope you have enjoyed this very brief history of Planning advancements in AI!