Udacity Artificial Intelligence Nanodegree

Project 3: Implement a Planning Search

Research Review

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Introduction

For this review, we've decided to focus on the major achievements in AI Planning and Search, which had great impact on the field as a whole. We start with the major breakthrough of STRIPS language and A* Search, then introduce ADL and PDDL which started expansion and standardization of STRIPS, and end with more recent work, with the use of distributed systems and coordination between multiple planning agents.

STRIPS and A* Search as a major breakthrough

Originally STRIPS was an automated planner developed at Stanford Research Institute (SRI) in 1971 and used in Shakey the robot, first general purpose robot able to reason about it's own actions. Shakey was able to analyze commands (end goals), and break them down into set of actions by itself. The revolution, however, came from the new language used to express the planning problem. The language consisted of initial state, goal states and actions made of preconditions (requirements) and postconditions (effects). Agent can then find the solution, by applying actions that satisfy the preconditions and adding/removing the postconditions from world state, until the goal is found.

Another result of the Shakey project was the A* search algorithm. By breaking the total cost of a node into the cost of the plan so far (from start to a node) and the heuristic cost (estimated cost from a node to end goal), it effectively combines the shortest-path finding algorithm like Djikstra or uniform cost search, with problem-specific heuristic (domain knowledge/estimation of the cost remaining). A* algorithm is used to this day and often considered more efficient than competitors [4].

ADL and PDDL as further development and standardization

Action Description language (ADL) is one of the many languages that followed STRIPS with the idea of improving it and allowing to handle more realistic problems. The language was developed in 1987 by Edwin Pednault as an attempt to find a middle ground between STRIPS and Situation Calculus [6][7]. Unlike STRIPS, ADL applies the concept of open world, where everything not occuring is unknown, instead of false. What's more, ADL allows negative literals and disjunctions in goals, as well as variable's types. It allows for greater expressiveness, which keeping the language restrictive enough that efficient reasoning algorithms can be developed.

The Planning Domain Definition Language (PDDL) was an attempt to standardize the planning languages. Developed in 1998 by Drew McDermott, to make the 1998/2000 International Planning Competition possible. By introducing one common language, it was possible to compare different planning systems and approaches, but also encourage research and development. "A common formalism is a compromise between expressive power and the progress of … research" [8]. Many variants and extensions to PDDL have been developed through time, like MA-PDDL (Multi Agent) or PPDDL (Probabilistic).

Distributed Systems and Multi-Agent Planning as a direction for the future research

Some of the problems can't be efficiently solved by full order planners. Some plans can be broken down into parallel chunks and executed concurrently. However, the most exciting research is in the area of multi-agent and distributed planners. The challenges in multi-agent planning are many. From environment (whether agents cooperate or compete), through tasks/goals assignment and division, to communication between agents.

One of the work related to Planning Search Project in AIND was [9]. Authors used the A* algorithm with a simple expansion of STRIPS to allow for multiple agents (MA-STRIPS model [10]), with the distributed and parallel variants separated by the choice of heuristics. Agents in the system have access to private as well as public actions, and have to exchange messages to potential pass work to other agents develop the optimal plan together.

We believe that given the rise of distributed platforms, and growing interest in decentralized resources and systems, this area of AI planning research will enjoy tremendous growth in the near future.

References

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