Research Analysis: Historical Developments in AI Planning and Search

Components Planning Problem

Automated Planning and Scheduling is one of the major files of AI. Planning focuses on building intelligent agents which realize a goal by executing a sequence of actions. The problem description has:

- **Initial State**: The initial conditions of the problem.
- **Goal State**: The final conditions that are required.
- **Actions**: Actions that can be executed to traverse from one state / set of conditions to a different state.

In such setup, there are different dimensions to the problem that we should be considered like:

- **Deterministic or Stochastic**: The environment and the actions executed can be completely deterministic or stochastic.
- **Fully or Partially Observable**: The environment can be fully or partially observable.
- **Multi Agent or Not**: There is a possibility that there are other intelligent agents in the system that effect our agent's actions.
- **Action Concurrency, Duration and Time**: The properties of the actions that can be executed play an important role in the solution.

Action / Planning Languages through history

History has seen development of lot of action / planning languages to describe the logic and execution involved in planning and search problems. **STRIPS** is an action language which was a part of the first major planning system. Originally STRIPS was a name for the planning component in software used in Shakey, the robot developed at the Stanford Research Institute (SRI), which was the first machine to be able to reason about its own actions. Shakey with his abilities (visual analysis, route finding, object manipulation and more) is called an ancestor of self driving cars, military drones, Mars rovers and overall field of Robotics and AI. As a part of this revolution, STRIPS planner gave Shakey the ability to analyse commands (the goals) and break them down into plan of all needed actions (even if Shakey itself wasn't be able to complete all of them). **ADL (Action Description Language)** is one of STRIPS extensions which removed some of its constraints to handle more realistic problems. Unlike STRIPS, ADL doesn't assume

that unmentioned literals are false, but rather unknown, what is better known as the Open World Assumption. It also supports negative literals, quantified variables in goals (e.g. ∃x At (P1, x) ∧ At(P2, x)), conditional effects and disjunctions in goals (all not allowed in STRIPS). Then came **PDDL (Planning Domain Definition Language)** which was an attempt to standardise planning languages what made International Planning Competition (IPC) series possible. In AI, hierarchical planning is use of different levels of abstraction in both planning process and in the description of the domain. An abstraction level is distinquished by granularity or fineness of detail in the descriptions of the world. Earl Sacerdoti developed one of the first planning programs, **ABSTRIPS**, and developed techniques of hierarchical planning.

Other Developments

Among the problems of initial algorithms are, **Sussman Anomaly** which was first described by Gerald Sussman. It illustrated problem related to noninterleaved planning, one where given two subgoals G1 and G2, produces either a plan for G1 concatenated with a plan for G2, or vice versa. In order to overcome this problem partial order planning or total order planning was developed. Partial-order planning is an approach to automated planning that leaves decisions about the ordering of actions as open as possible in contrasts to total order planning ordering is preserved. A **partial-order plan** or partial plan is a plan which specifies all actions that need to be taken, but does not specify an exact order for the actions when the order does not matter. There are other ways suggested for solving planning problems which are by **reduction to proportional satisfiability problems** or **reduction into model checking**.

References

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