A Quick Overview: Advancements in AI Planning

Motivated by the necessity as well as various advancements in devising solutions to challenging yet practical and vital tasks, AI Planning has emerged as a general framework that provides some guiding principles to unsupervised search towards achieving a desired goal. As with any other domains, it went through various interesting developmental stages before reaching this current shape. A summary of such major milestones is listed and discussed.

Action Representation:

- Concerned mainly with problem formulation.
- Strict rules were established by STRIPS, and was later relaxed in Action Descript Language (ADL).
- The Problem Domain Description Language (PDDL) was then introduced as an attempt to standardize various practices learnt from other languages. [1]

Goal Regression and Partial Order Planning:

Linear planning was formalized by Sacerdoti [2-4] as a continuation of many previous efforts, was proven to be incapable of handling simple problems like the Sussman anomaly [1]. Goal regression planning [5] was introduced to tackle the shortcomings of linear planning and allowed plan reordering **to avoid conflict** among sub-goals.

Sub-goal **conflict detection**, was possible with **partial order plans** (task networks), that searches the plan space to provide choices that are relevant to solving the current part of the problem [6]. The following are the main highlights in **Partial Order Planning** (POP)

- NOAH [3] is considered the first non-linear partial order planner. It uses a Table of Multiple Effects to detect goal interactions and introduced plan space search.
- Modal Truth Criterion (MTC) [7] attempted to provide a formal basis for partial order planning. It has been used later to generate planning algorithms. Many of misconceptions regarding the role of MTC, as well as several terminology corrections were highlighted later in the work of [8].
- **SNLP** presented an efficient way to determine which preconditions could be achieved [9]. It handles partial order planning in a systematic way that prevents generating redundant plans and consequently reduces the search space [10]. It has enabled researchers to understand and experiment with partial order planning for the first time [1].

- The Universal Conditional Partial Order Planner (**UCPOP**) [11], is an extension to **SNLP** and uses additional operators like unification to find necessary bindings. It utilized constraint satisfaction to improve consistency of plans [6]. It also incorporated the notion of number of unsatisfied goals heuristic [1].

- Several novel **heuristic techniques** was introduced by [12] and proved that partial order planning may achieve high scalability and ***could compete*** with state of art plan synthesis algorithms. They implemented their ideas in a variant of **UCPOP** called **RePOP** and reported outperforming **Graphplan** in several parallel domains.

Graphplan System:

Aims at finding a sequence of operations for reaching a goal state given an input planning problem. It utilizes graphs to reduce the search space. The method introduced in [13] had a great impact in the research community and launched a whole series of research efforts to enhancing its performance or via extending its scope with more expressive planning languages [14] .

Heuristic Approaches

Kautz and Selman in [15] developed a formal model of planing based on **statisfiability** rather than deduction. Their approach provided more flexibility for handling various constrains on plans. The method benefited from various advances in **propositional resoning systems** [14].

Heuristic search planning [16] devises a heuristic to guide the search according to various observations in the problem domain. Kautz and Selman suggested combining a general **stochastic serach algorithm** and appropriate **problem encodings** based on **propositional logic** and reported fast and successful planning solutions [17]. Hoffmann and Nebel in [14] described and evaluated a number of techniques that are used in **Fast Forward (FF)** planning systems that mainly rely on a heuristic that estimates goal distances by ignoring delete lists.

Recent Related Trends:

Recent development in this regard include merging a number of meta-heuristic bioinspired algorithms like in [18-20]. There is also an increased interest in utilizing Neural Netowrks in search planning problems [21, 22]

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