Research review on the field of AI planning and search

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The field of planning in artificial intelligence emerged from the integration of practices in separate domains such as state-space search, theorem proving and control theory, incentivized by the practical needs of robotics, scheduling and other domains. As in any other research field, knowledge was constructed through a series of developments made by a large number of researches and its intricacies and impacts are cumbersome for describing. This report focus on three of these developments: STRIPS system, Planning Domain Definition Language and the GRAPHPLAN algorithm.

Problems in which the solution is to be found by searching through the space of world models, and consists in a set of operations that transform the world, given an initial model, was central to much of the research in artificial intelligence by the 1960s and 1970s [3]. In 1969 Green introduced an application of theorem-proving to problem solving, which relied solely on formal inference to search for appropriate sequence of actions, though the "frame problem" prevented it from solving problems with more complex world descriptions and action constraints.

In 1971 a novel approach to problem solving was introduced by Fikes and Nilsson with the program STRIPS. The system is a problem solver that combines formal theorem-proving methods with a search algorithm so to find a sequence of operators in a space of world models. The system completely separates the two processes, which allowed to employ separate strategies for them, yielding improvement in performance. Theorem-proving methods were used only within a given world model to find applicable actions and test if a given model satisfies the goal condition. This combination allows world representations much more complex and general than any of those in GPS and provides more powerful heuristics than those found in theorem-proving programs. [2]

As mentioned by Russell and Norvig, the representation language presented by the program influenced future systems and representation structures in the field, most notably the Planning Definition Language (PDDL) introduced by the AIPS-98 Planning Competition Committee, with the goal of "... encourage empirical evaluation of planner performance, and development of standard sets of problems all in comparable notations." [4]

PDDL has been the standard representation language for the International Planning Competition since it was introduced, and allows for problems with world models and constraints much more complex than previous languages.

The paradigm introduced by the STRIPS program (search in the state-space with theorem-proving methods for choosing applicable actions and goal test) was extensively used, but its limitations regarding the impossibility for interleaving of actions, which makes it incomplete, pressured the field to focus its research in partial-order programs for the next 20 years. Only in the 1990s state-planning resurged, along with the introduction of a new data structure (Ghallab and Laruelle, 1994) that would later influence the creation of graph-planning systems.

GRAPHPLAN was introduced by Avrim Blum and Merrick Furst 1996 and revitalized the field of planning, as stated by Russell and Norvig. This new approach comprised of constructing and analyzing a structure the creators called planning graph. Differently from a state search graph which is exponential

in size, the planning graph encodes possible world literals into levels, transforming an exponential search into a polynomial one. Blum and Furst showed evidences that GRAPHPLAN outperforms the total-order planner Prodigy and the partial-order UCPOP. [5]

References

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