Planning and search: an historical review

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There have been many advances in the field of Artificial Intelligence (AI) that evolved from planning and search algorithms.

Prolog language, developed by Alain Colmerauer and Philippe Roussel in the early 1970s, was one of the core advances. It was designed as a declarative language, where the program logic is expressed in terms of relations, represented as facts and rules. Prolog main goal was to apply logic inference in the field of Natural Language Processing (NLP), but it has been used in multiple expert systems and other AI systems.

The reader must be surprised that a language that was developed almost 50 years ago is used in one of the most powerful AI systems existing nowadays: IBM Watson. Watson is a Questioning-Answering system that beat two former champions in the Jeopardy challenge in February 2011, showing to the general public that an AI system could outperform humans in a wide context task. One of the main components of Watson is an NLP module that can understand a regular "human" question and narrow down the contexts that can lead to the right answer in a very short time. This module was developed in Prolog language. Quoting some of the authors, "we required a language in which we could conveniently express pattern matching rules over the parse trees and other annotations (such as named entity recognition results), and a technology that could execute these rules very efficiently. We found that Prolog was the ideal choice for the language due to its simplicity and expressiveness" [1].

In parallel to the Prolog foundation, Fikes and Nilsson developed the STandford Research Institute Problem Solver (STRIPS) [2], which was of huge relevance in the field of problem planning. This planner introduced the *Strips Assumption* as a way to simplify the frame of a planning problem within the situation calculus. The assumption is that the only changes that arise on application of an action to a situation are those that are explicitly mentioned as positive effects of the action. This principle continues to be of key importance in the modelling of planning problems.

During the 70s and 80s, the effort was focused on puzzle-like problems. Two approaches for solving these problems confronted: classical domain independent planning versus application-oriented planning. The latter seemed a more practical approach that reached good results in some problems, but both lines improved consistently and led to significant advances. Some of the most important advances were Graphplan (1995) [3] and the forward search planner HSP [4] (1997), which created a lot of excitement. However, it soon seemed clear that no “pure” approach could be a clear winner, and therefore some hybrid approaches (combination of planning techniques with other domains techniques) and hand-coded control rules, complemented the development of the field.

Planning search techniques have been used in complex applications in the last years. Some examples include manufacturing processes [5], satellite and spacecraft operations planning [6-9], elevator scheduling [10], evacuation planning [11], etc. However, these applications require an important knowledge of the specific domain, and dealing with uncertainty remains as one of the major challenges in the use of planning and search techniques.

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