Key Developments in AI Planning and Search

STRIPS

STanford **R**esearch **I**nstitute **P**roblem **Solver** was developed by Richard Fikes and Nils Nilsson in 1971[1] as an automated problem solver. The STRIPS problem space consists of the initial state, a set of operators (actions) and their effects on the world state. Initial and goal states were represented using full first order logic and other states used a subset of the logic:

- Only AND connective (negation included)
- No variables or functions

STRIPS reduces the size of the search space to increase the efficiency of planning. First, only preconditions of the **last action added** are allowed to be worked on. Secondly, backtracking over operators whose preconditions are satisfied by the initial state is not allowed[2]. For most problems this was successful and STRIPS produced valid solutions, however it causes STRIPS to be **incomplete** as it could not find all solutions to a problem - leaving some problems unsolvable. The main legacy of STRIPS was the problem representation language used.

PDDL

Planning **D**omain **D**efinition **L**anguage is a standard encoding language for classical planning tasks[3]. It was heavily inspired by the STRIPS representation language and aimed to provide a common, standard formalism for describing planning problems. It separated the problem definition into two sections:

- Domain Definition
  Predicates - Properties of objects the problem is concerned with
  Actions
- Problem Definition
  Objects - 'Things' in the world the problem is concerned with
  Initial State
  Goal State

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[1] "STRIPS - Stanford Artificial Intelligence Laboratory."
http://ai.stanford.edu/~nilsson/OnlinePubs-Nils/PublishedPapers/strips.pdf. Accessed 21 Nov. 2017.
[2] "2. STRIPS Planning Algorithm Pseudocode Actions Example Example."
http://www.cs.bham.ac.uk/~rwd/Planning/slides-3.pdf. Accessed 21 Nov. 2017.
[3] "An Introduction to PDDL." https://www.cs.toronto.edu/~sheila/2542/s14/A1/introtopddl2.pdf. Accessed 21 Nov. 2017.

PDDL provided a common standard for search problems and allowed the International Planning Competition to be founded - leading to further developments in the field.

WARPLAN

A case-based planning system created by David Warren in 1973[4]. It optimally solves the Sussman Anomaly (which STRIPS and other non-interleaved systems suffered from) through implementing **interleaving of actions** from different 'sub-plans' within a single sequence. Interleaving was achieved by using goal-regression planning - steps in a totally ordered plan are reordered so as to avoid conflict between subgoals[5].

In addition, WARPLAN is notable for being the first planning system to be implemented using the Prolog logic programming language. It used only 100 lines of code and was one of the first true demonstrations of the strengths of logic programming.

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[4] "AI Qual Summary: Planning - Duke Computer Science."
https://www.cs.duke.edu/brd/Teaching/Previous/AI/Lectures/Planning/planning.html. Accessed 21 Nov. 2017.
[5] "Artificial Intelligence: A Modern Approach." pg. 394 26 May. 2016, http://aima.cs.berkeley.edu/. Accessed 21 Nov. 2017.