Historical Developments in The Field of AI Planning and Search

Research Review by Suresh Ooty

AI Planning & Search: 'Historically, planning has been considered different from problem solving; however, the distinction seems to have faded away in recent years' (2). The planning algorithms & searching could be applied a wide range of scenarios such as, Discrete Puzzles, Motion planning puzzle, an automotive assembly puzzle, navigating mobile robots, mobile robot games such as hide & seek, virtual humans / humanoid interfaces, parking car modules & algorithms for self-driving cars, flying drones through continuously changing space, etc., In recent years, the penetration of Planning Algorithms has been perpetual and the applications have become common in the form of 'Self Driving Cars', ' Drones', 'Cleaning Robots', 'Human interfaces such as Alexa, Ok Google', etc.,

There has been traction on 'Planning Algorithms' since 1970s. The initial planning systems came out of investigations 'into state-space search, theorem proving, and control theory and from the practical needs of robotics, scheduling, and other domains.' (1)The Planning Algorithms started to evolve as 'Searching' Algorithms initially and became a planning system with logical goals & sub-goals in a sequential order. The challenges such as 'non-interleaving' sub-goals made the algorithms incomplete. Such challenges were overcome with the application of 'Partial order Planning'. Application of 'heuristics' to optimize the search space also improved the algorithms. 'Constraint' based algorithms helped algorithms to effectively reduce the search space.

Today, Planning Algorithms consists of

(a) A definition language – that describes the problem descriptively with preconditions and effects
(b) Searching methods that applies effective methods to optimize the search space heuristically and by the application of constraints (specified as preconditions & effects using definition language)
(c) A planning graph of state space, with literals and actions connecting parent & children of states & actions.

There are researches on representing the plans as 'binary decision diagrams', a compact data structure in hardware verification community (1). It would not be surprising if there are trying to apply the usage of GPUs or other intensive computing devices for plan representations in hardware effectively.

AIMA states that 'constraint-based approaches such as GRAPHPLAN and SATPLAN are best for NP- hard domains, while search-based approaches do better in domains where feasible solutions can be found without backtracking' (1)

Evolution of Algorithms: AIMA (1) discusses the evolution of languages and algorithms that evolved on AI planning & search over the past 50 years.

Languages used in AI Planning space

year	Name	Remarks
1986	ADL - Action Description Language	*Relaxed STRIPS constraints - more realistic problems
1998	PDDL - Problem Domain Description Language	* used in International Planning competitions since 1998 * recent extended to PDDL 3.0 (2005)

Planning Algorithms over years

year	Name	Remarks
1961	GPS	*A General State Space Search System
1971	STRIPS	* First Major Planning System * Part of Planning system at SRI (Shakey Robot project) * Using GPS * In 1993 - it was found as PSPACE complete
1975	Linear Planning Approach	found incomplete as it is 'non-interleaving of sub-goals
1975	WARPLAN	* using Prolog * uses Goal-Regression Planning to handle 'interleaving'
1975	NOAH planner / NONLIN systems	* called as Task Networks' * uses partial order planning
1987	TWEAK	* proofs of completeness & intractability
1991	SNLP	* uses complete partial order planner (extension TWEAK)
1992	UCPOP	* uses complete partial order planner (extension TWEAK)
1996	UNPOP	* uses ignore delete-list heuristics
1996	GRAPHPLAN	* faster than POP (partial order planners)
	Other graph planning systems	IPP - 1997 STAN - 1998 STG - 1998

1991	CPLAN	* description of planner based on constraint satisfaction
2001	REPOP planner	* better than GRAPHPLAN * competitive with fastest state space planners
2000	FF	Winner of AIPS 2000 competition
2002	LPG	* winner 2002 * local search technique inspired by WALKSAT
2004	FASTDOWNWARD	* winner 2004 * uses forward search
2008	LAMA	* winner 2008 * uses forward search with heuristics

Reference:

1. AIMA Chapter 10 – Bibliographical & Historical Notes
2. Planning Algorithms (LaValle 2006)