AIND: Planning Search – Research Review

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Abstract

A quick survey on three important historical developments in the field of AI planning and search.

1 Standardized planning problem definition languages

The STRIPS planner (*Stanford Research Institute Problem Solver*, Fikes and Nilsson, 1971) introduced a formal language consisting of a 4-tuple of set of conditions, operations, a start state and a goal state (of true and false literals) under a closed-world assumption (i.e. every unmentioned literal is implicitly false). The later developed ADL (*Action Description Language*, Pednault, 1989) added the notion of negative literals in states, the open-world assumption (an unmentioned literal has an explictitly unknown truth value), as well as disjunctive goals and types. In 1998, the Planning Domain Definition Language PDDL (Ghallab et al., 1998) defined a standard language for planning problems and is currently available in version 3.1 (e.g. Kovács, 2014). PDDL adds object hierarchies, domains and requirements, conditional effects, continuous actions, constants and fluents.

2 Planning partially ordered plans

NONLIN and SNLP planners added the ideas of planning partially ordered subplans rather than operating directly on the state space (compare Russell and Norvig, 2009). The idea here is that actions can be combined into smaller plans, or tasks, which can be more efficiently reasoned about. By relaxing the strict ordering of plans into a partial ordering, plans were now able to be partially executed in parallel. While tasks are not (necessarily) determined on-line, this relates with the idea of decomposing the search space into individually solvable parts and pattern databases.

3 Monte-Carlo search and adversarially learned heuristics

In the field of domain-specific (tactical) plans in closed-world adversarial scenarios, the algorithm implemented for the AlphaGo problem of playing Go against a human opponent (Silver et al., 2016) combines (ad hoc) depth-first state-space Monte-Carlo search (e.g. Browne et al., 2012) with a learned heuristic function implemented using a deep convolutional neural network. In addition to only stochastically sampling the space of possible solutions in order to quickly approximate the probability of a positive outcome given a specific action, a neural network has been trained to predict the value of a specific action given the current world state both in a supervised fashion on known outcomes provided by human experts, as well as using reinforcement learning techniques such as deep Q learning against time-lagged (i.e. older) versions of itself.

While this kind of planning is not directly applicable to generic plans, it sort of resembles the GraphPlan (Blum and Furst, 1995) approach of quickly determining a rough estimate of the outcome of selecting a specific action. Rather than sampling all possible applicable actions per node, only a random subset is selected, decreasing execution time.

References

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