HTN IPC-2020 Domains: Blocksworld-HPDDL and Multiarm-Blocksworld

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Abstract

The Blocksworld-HDDL problems from the 2020 HTN International Planning Competition were adapted from the HTN translation papers by Alford et al.. The domain enforces a strategy of only picking up blocks to move, and placing them either in their final location or on the table. The Multiarm-Blocksworld domain extends the domain by allowing for multiple independent arms.

The Blocksworld-HPDDL domain was introduced by the 2009 translation of totally-ordered HTN problems to PDDL (Alford, Kuter, and Nau 2009). Blocksworld-HPDDL was supplemented by the Multiarm-Blocksworld domain in further work translating partially-ordered HTNs to PDDL (Alford et al. 2016). These domains were designed to test the effectiveness heuristic search when using control knowledge to eliminate the Sussman Anomaly from the standard Blocksworld's search space.

The IPC problem files are generated with the uniform Blocksworld state generator by Slaney and Thiébaux (2001), and converted to the HDDL problem format. Each of the problem initial states is supplemented with predicates describing the goal (e.g., `(goal_on a b)` if `(on a b)` is part of the goal state). The HTN IPC contained 30 problems from this domain with a block count ranging from five to 1,000.

The domain has a top level task `(achieve-goals)`. At a high level, it loops through blocks which aren't marked as `done` (i.e., for a block `b`, `(done b)` is part of the state). For each block `b` where `(done b)` is not part of the state:

- If `b` is on the table and has a goal of being on the table, `(done b)` is added to the state.
- If `b` is on a block `c`, `(on b c)` is part of the goal state, and `c` is marked as `done`, then mark `b` as `done`.
- If `b` is clear, on another block, and its goal location is clear (or on the table), then pick up the block, place it in its goal location, and mark it `done`.
- If `b` is clear and its goal location is not, pick up the block and set it on the table.

Preconditions to the four `achieve-goals` methods prevent them from selecting a block which isn't ready for any of the four methods. For any solution to the original Blocksworld domain, this method structure permits a solution with the same or fewer total `pickup`, `putdown`, `stack`, and `unstack` actions by eliminating unnecessary moves and replacing some stacks with table placements.

In structure, the `achieve-goals` task is tail-recursive with a max progression bound of 4, strictly limiting the size of task networks that HTN-progression oriented planners will encounter during search (Alford, Bercher, and Aha 2015). There are 12 methods and 6 operators, four of which are the original actions of Blocksworld, and two of which are bookkeeping operators.

The Multiarm-Blocksworld extends the original Blocksworld domain by adding independent arms to the environment. The HTN method structure is the same. To add the arms, each of the methods and placement operators is given an additional `arm` parameter, and the initial task network contains an `achieve-goal` task for each arm. In the HTN IPC, this domain was used in the total order track, where the `achieve-goals` tasks were serially ordered. This meant that the IPC Multiarm-Blocksworld problems have the same effective solution space as the Blocksworld-HPDDL domains.

References

[Alford, Bercher, and Aha 2015] Alford, R.; Bercher, P.; and Aha, D. 2015. Tight bounds for HTN planning. In *ICAPS*.

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