Cerberus Planner: Back In Action

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Abstract

The planner *Cerberus* has participated in the International Planning Competition (IPC) 2018. The planner exploits red-black planning heuristic with a direct handling of conditional effects, using it as a base for a novelty heuristic. Herein, we describe the particular configuration choices made this year.

Introduction

Red-black planning (Domshlak, Hoffmann, and Katz 2015) is a convenient method of interpolating between fully relaxed and regular planning, allowing for partially relaxing a planning task while remaining in a tractable fragment of planning. Starting with the work of Katz, Hoffmann, and Domshlak (2013b), which introduced the red-black framework and conducted a theoretical investigation of tractability, follow up work devised practical *red-black plan heuristics*, generated by repairing fully delete-relaxed plans into red-black plans (Katz, Hoffmann, and Domshlak 2013a). To overcome the issue of over-estimation incurred by following arbitrary decisions taken in delete-relaxed plans, Katz and Hoffmann (2013) show how to rely less on such decisions, yielding a more flexible algorithm delivering better search guidance. Subsequently, Katz and Hoffmann (2014b) presented a *red-black DAG heuristics* for a tractable fragment characterized by *DAG black causal graphs*. Interestingly, they show an extremely simple and efficient enhancement, targeting at making the resulting red-black plans executable in the real task and stopping the search if they succeed in reaching the goal. Red-black DAG heuristics are in the heart of, among other, the *Mercury* planner (Katz and Hoffmann 2014a), the runner-up of the sequential satisficing track in the latest International Planning Competition (IPC 2014). All aforementioned work on red-black planning, however, handles the SAS$^+$ fragment without conditional effects, despite of conditional effects being a main feature in the domains of IPC 2014. The planner *Mercury* that favorably participated in IPC 2014, handles conditional effects by simply compiling them away (Nebel 2000). Recently, Katz (2019) has shown that the fragment of red-black planning characterized by *DAG black causal graphs* remains tractable in the presence of conditional effects, extending the existing red-black planning heuristics to natively handling conditional effects. This native support of conditional effects was integrated into the *Cerberus* planner (Katz 2018), which participated in IPC 2018.

Another feature of *Cerberus* is the use of a search pruning technique based on the concept of *novelty* of a state, where the search procedure prunes nodes that do not qualify as *novel*. *Cerberus* exploits the novelty of a state with respect to its heuristic estimate (Katz et al. 2017). The notion was no longer used solely for pruning search nodes, but rather as a heuristic function, for node ordering in a queue. Since such heuristics are not goal-aware, *Cerberus* uses the base red-black heuristic as a secondary (tie-breaking) heuristic for node ordering.

In addition, *Cerberus* in IPC 2018 has used the h^2 mutex detection (Alcázar and Torralba 2015) while translating from PDDL to SAS$^+$. Consequently, the planner *Cerberus* was named after the monstrous three-headed guardian of the gates of the Underworld in Greek mythology. The planner was submitted to both the satisficing and agile tracks. While in the satisficing track its performance was among the top single-component planners, in the agile track it performed poorly. Our analysis indicates that switching off the h^2 mutex detection significantly improved performance. In what follows, we describe the configurations submitted to each of the tracks.

Satisficing Track

The configuration submitted to this track mirrors precisely the configuration of *Cerberus* from IPC 2018. In this configuration, the red-black planning fragment for heuristic computation was created by iteratively painting invertible variables red until the black causal graph becomes acyclic (Domshlak, Hoffmann, and Katz 2015).

Agile Track

The configuration submitted to this track differs from the configuration of *Cerberus* from IPC 2018 in one aspect. The h^2 mutex detection was not applied this time. Here as well, the red-black painting strategy is iteratively painting invertible variables red until the black causal graph becomes acyclic.

Post-IPC Analysis

International Planning Competition (IPC) 2023 introduced 7 domains: *folding*, *labyrinth*, *quantum-layout*, *recharging-robots*, *ricochet-robots*, *rubiks-cube*, and *slitherlink*, with 20 instances in each. Here, we present some observations about planners behavior on these domains. First, note that the translator component used by the planner is used by both agile and satisficing variants, while the preprocessing component (h^2 mutex detection) is used by the satisficing variant only. Translator fails on 16 instances of *labyrinth*, 3 instances of *recharging-robots*, and all 20 instances of *slitherlink*. On additional 12 instances of *recharging-robots* the translator creates axioms, which are not supported by the search component. In these cases, axioms are avoidable. The preprocessor fails on the remaining 4 instances of *labyrinth* and 5 instances of *folding*.

Red-black heuristic extends the FF (Hoffmann and Nebel 2001) heuristic by considering delete effects of RSE-invertible variables (Domshlak, Hoffmann, and Katz 2015). Such variables are found in all domains where search could start, except for *rubiks-cube*. In the latter domain, the red-black heuristic values returned were essentially equivalent to the FF heuristic ones.

Conclusions

The domains introduced in IPC 2023 are significantly different from the previously existing ones. In order to be able to efficiently handle tasks in these domains, the planner should be adapted to use a more efficient translator and preprocessor. It might be worth exploring whether a more general definition of invertibility can be applied to the *rubiks-cube* domain.

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