Enhancing Temporal Planning by Sequential Macro-actions: Extended Abstract

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1 Introduction

Temporal planning is a framework dealing with concurrent actions and timing requirements, providing an intuitive syntax for representing planning domains, such as PDDL 2.1 [5], together with off-the-shelf planners, e.g., Optic [1], to generate plans. However, with larger numbers of tasks and/or resources to operate and synchronize, the performance of (temporal) planning engines tends to sharply deteriorate, which limits their usability for practical problem solving. As a possible remedy for the scalability issue, we provide a general concept of sequential temporal macro-actions, i.e., macros encapsulating sequences of durative actions, where preconditions, invariants, and effects are assembled in a fine-grained way to enable concurrent execution when it does not compromise the macro-action applicability. We evaluate our approach using state-of-the-art planners on domains from the International Planning Competition as well as the RoboCup Logistics League, obtaining improvements in coverage and in some cases also plan quality. This extended abstract summarizes the main contributions of our JELIA'23 paper [2], an extended version of which is also available online [3].

2 Sequential Macro-actions

We illustrate our construction of macro-actions on an example and refer to [3] for formal definitions, related theorems and proofs. Let us consider Figure 1, visualizing how two actions from a simple temporal domain are composed into a macro-action. The actions at the top involve an agent r capable of moving from a location $l1$ to $l2$ for picking up an object at location $l2$. First observe that the macro-action displayed at the right of Figure 1 pulls the delete effects applied at the end of the $move$ or at the start of the get action, i.e., $(not\ (free\ l2))$ and $(not\ (empty\ r))$, together with the original start effects of the $move$ action. The positive end effect $(at\ r\ l2)$ of the $move$ action, however, joins $(holding\ r)$ at the end of the composed macro-action. In general, the early application of delete effects and postponement of add effects prevent that other actions, building on the volatile atoms affected by macro-internal events, are applied.

Preconditions at the start of the macro-action include the original $(at r l1)$ atom from $move$ together with $(free\, l2)$ and $(empty\, r)$ required at the end of $move$ or at the start of get, respectively. The reason for not turning the latter two atoms into invariants required throughout the macro-action is that their negative literals occur as new start effects, so

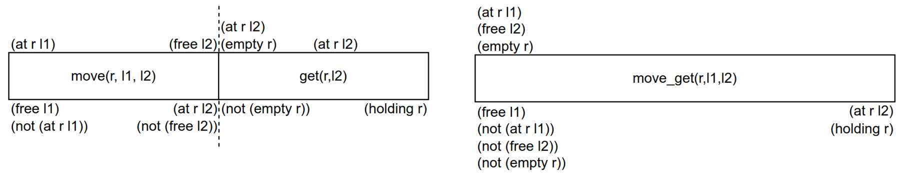

Fig. 1: Description of two actions and the resulting macro. Literals below each action represent effects, while the literals above them provide preconditions (at the start, end, or during an action, as indicated by their positions).

that invariants would render the macro-action inapplicable. Moreover, the precondition and invariant $(at\ r\ l2)$ of get is not taken as a precondition or invariant of the macro-action since it is enabled by the end effect of $move$, which is now postponed to the end of the macro-action. In fact, considering that any other actions in the domain will hardly admit $(at\,r\,l1)$, which is a precondition at the start, and $(at\ r\ l2)$ to hold simultaneously, turning the latter into a precondition or invariant would most likely yield an (unnoticed) inapplicable macro-action. Moreover, the macro-action composition introduces mutex atoms (omitted in Figure 1 for better readability) to guarantee that unfolding macro-actions back into the original action sequences always yields an executable refined plan.

3 Discussion

We developed a Java tool[1] that performs the composition of macro-actions at the level of first-order PDDL domains. Our experimental evaluation [2,3] shows that equipping domains with macro-actions can change the landscape of heuristic features, having an impact on the quality of solutions and how fast planners can find them. The particularly positive effects on the RoboCup Logistics League domain [4] show that replacing a large portion of ordinary actions by macros can significantly improve the planner performance and plan quality. On the other hand, mixed outcomes on the Road Traffic Accident Management, Driverlog, and Satellite domains from the International Planning Competition [7] also indicate that the overhead due to mutex atoms introduced by macro-actions can outweigh performance gains when many ordinary actions remain.

In contrast to classical planning, very few works consider macro-actions in the context of temporal planning. A technique to generate macro-actions out of partially overlapping temporal actions is presented in [8], yet without ensuring that the obtained plans are executable. The most recent approach to define temporal macro-actions stems from a master thesis [6], but the used model of durative actions deviates from PDDL 2.1. Our work provides a general concept of sequential macro-actions for temporal planning that guarantees the applicability of underlying action sequences and turns out to be particularly advantageous for logistics domains, while it is not conceptually restricted to them.

As future work, we want to develop methods to automatically detect suitable candidates for macro-actions in a given domain. Moreover, the formalization of further kinds of macros in temporal planning, like parallel or, more generally, overlapping macro-actions and support for numeric fluents, constitutes an interesting future work direction.

[1] `https://gitlab.com/mbortoli/temporalmacro`

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