A new set of temporally-expressive benchmarks

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Abstract. All the domains and problems which have been used up until now in the temporal track of the IPC competitions are temporally-simple. The winning planners in the IPC competitions, even if they are efficient in a restricted temporal framework, are therefore far from capable of solving real-world problems. The objective evaluation of these systems requires the setting up of new benchmarks corresponding to temporally-expressive problems. We propose here several of these new benchmarks.

Keywords. Temporal planning, temporally-expressive problems.

1. Recent theoretical studies

Although many temporal planners have been built and compared in IPC competitions, several problems remain which prevent them from being used effectively to solve real applications. They are only complete for certain sublanguages of PDDL2.1 [Fox, Long, 2003] which can eventually be reduced to STRIPS [Cushing et al., 2007.a]. Therefore, they can only solve those problems for which there is a sequential solution (temporally-simple problems). However, almost all real-world problems, even if they can be solved by essentially sequential plans, require concurrent actions at some moment or other. In order to be able to envisage real applications, one must represent and solve problems for which all possible solutions require parallelism (temporally-expressive problems) [Cushing et al., 2007.b].

Recent theoretical studies have brought to light the limitations of the current approaches to temporal planning. [Cushing et al., 2007.b] show that the domains and problems which have been used up until now in the IPC competitions are temporally-simple and they propose a method to prove that a domain is temporally-expressive. The winning planners in the IPC competitions, even if they are efficient in a restricted temporal framework, are therefore far from capable of solving real-world problems. The objective evaluation of these systems requires the setting up of new benchmarks corresponding to temporally-expressive problems. [Rintanen, 2007] prove that solving such problems is EXP-SPACE complete.

2. Benchmarks

Given that the IPC competition benchmarks were inappropriate, since temporally-simple, we drew up several new temporally-expressive benchmarks. All these benchmarks can be found at the adress which is given below[1].

2.1. Temporally-expressive problems in PDDL 2.1

The first test domains extend the problem of [Cushing et al., 2007.a, figure 3] in three different ways:

- the **"tempo-depth-n"** problems extend the original problem over a greater number of levels. The solution-plan requires n stages, each composed of triples of concurrent actions.
- the **"tempo-width-m"** problems require m triples of concurrent actions over only three levels order to achieve the goal.
- the **"tempo-matrix-n×m"** problems combine the difficulties of the above two cases.

[1] http://tlpgp.free.fr/benchmarks.html

2.2. Problems using richer durative actions

These problems use richer durative actions defined in [Smith, 2003]. The **"tms-k-t-p"** problems (temporal machine shop, [Cushing et al., 2007.a]) is inspired by a real-world application. It concerns the use of k kilns, each with different baking times, to bake p ceramic pieces (bake-ceramic) of t different types. Each of these types requires a different baking time. These ceramics can then be assembled to produce different structures (make-structure). The resulting structures can then be baked again to obtain a bigger structure (bake-structure). We have defined too a "light" version of these domain for temporally-expressive planners which do not support richer durative actions.

The **"cooking"** domain allows to plan the preparation of a meal, as well as its consumption by respecting constraints of warmth. Problems cooking-carbonara-n allow to plan the preparation of n dishes of pasta. The concurrency of actions is required to obtain the goal because it is necessary that the electrical plates works so that water and oil are hot enough to cook pasta and bacon cubes. It is also necessary to perform this baking in parallel to serve a hot dish during its consumption.

2.3. Problems using new extensions for durative actions

To represent real-word domains, we have defined a more expressive language in which we can represent the fact that a precondition or effect p must be true (and not p false) during a minimal duration d anywhere within an interval [a,b]. Our language also allows the user to disassociate p and not p by stipulating, for example, that p must be true at the end of an interval [a,b] over all of which not p cannot be established.

The **"temporal-machine-shop-2-3"** domain extends the "tms-2-3" domain. The action fire-kiln is now described using (somewhere [start (+ start 1)] (ready ?k)) to express the fact that the kiln will be ready at an unknown instant between start and start + 1. The expression (over [(+ start 1) end[(ready ?k)) is used to enforce the kiln to be ready up to the end. Moreover, the time wich is necessary to bake a ceramic is not completely known and can be represented using (somewhere [(- end 5) end] (baked ?p)).

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