Using ASP for Model-based Diagnosis

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Abstract. In this paper, we outline the use of answer set programming for diagnosis, i.e., the localization of faults. In particular, we reference related articles introducing the ASP coding of models for diagnosis and an algorithm that allows computing all minimal diagnoses up to a predefined size.

Keywords: Diagnosis · Model-based reasoning · ASP modeling for diagnosis.

1 Extended abstract

Diagnosis comprises detecting faults and identifying their underlying reasons. In the early years of artificial intelligence, expert systems were used for diagnosis. Such expert systems code knowledge in the form of an "effect to cause" rule to enable using deduction directly for identifying a root cause. However, other techniques have been suggested because of disadvantages like requiring reformulating available diagnosis knowledge accompanied by additional costs. Reiter [3] formalized diagnosis as a non-monotonic reasoning problem where the fault mode, i.e., *ab* (standing for not abnormal), is explicitly used in component models. In Reiter's approach, a model comprises structural information, i.e., the interconnection between components, and the behavioral model of a component, where we assume that the component is working as expected, i.e., $\neg ab$ (not abnormal). A diagnosis, accordingly to Reiter, is a set of components when assumed to work correctly, will not contradict the given observations together with the system's model. Hence, for diagnosis, we assign certain *ab* predicates to true and others to false. For diagnosis, specialized algorithms have been suggested, allowing all diagnoses up to a given size to be computed within seconds, even for larger systems comprising several hundreds of components.

Wotawa [4] introduced a coding of models utilizing answer set programming (ASP) (see [1]). The underlying idea is simple. We use the *ab* predicate and introduce its negated predicate *nab*. The latter is used when specifying the component model of correct behavior. In addition, we introduce the following two rules:

```
nab(X) :- comp(X), not ab(X).
ab(X) :- comp(X), not nab(X).
```

In these rules, the predicate *comp* states that the value of variable X has to represent a component. With these rules, the answer set solver will select *ab* and *nab* values for the component X such that any answer set is consistent. This way, the *ab* predicates in the answer set represent the components. To compute minimal diagnoses, we have to add additional information on smaller diagnoses and introduce means for defining the number of components, allowing us to further select computing only single or double faults. In `clingo`[1] this information can be formalized as follows (for single fault diagnoses):

```
no_ab(N) :- N = #count { C : ab(C) }.
:- not no_ab(1).
```

For more information, we refer the interested reader to our more recent publications [2, 5] where we discuss the ASP coding in detail and compare the ASP diagnosis algorithms with other algorithms showing that ASP can deliver double and triple fault diagnoses where different approaches cannot within reasonable time limits.

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[1] See `https://potassco.org/`