Extending the Modeling Framework for Abductive Diagnosis Beyond Horn Clauses

ROXANE KOITZ AND FRANZ WOTAWA

|EKOITZ,WOTAWA|@IST.TUGRAZ.AT

ABSTRACT

Model-based diagnosis relies on a formalization of the system to be diagnosed, which has to characterize the underlying artifact accurately, provide information vital for the diagnostic task, and allow computing solutions efficiently. A common constraint of diagnosis engines is to restrict the model to comprise Horn clauses. There are, however, practical applications where this limitation is problematic as the failure behavior of the system would require a more expressive representation. In this paper, we describe a modeling method for abductive diagnosis based on an extension of Horn logic, which allows expressing conjunctions and disjunctions of effects. We present a mapping from this representation to a Horn theory since such a model can be applied to a wide range of diagnosis algorithms. Diagnosis based on the converted models provides intuitive explanations similar to human reasoning, which are beneficial in the context of practical fault identification. In addition, we present initial empirical results.

MOTIVATION

We conclude that:

- there could be lack of fuel or the engine could be broken
- the battery must be charged as the starter is working

But there might be enough power in the battery for the starter but not for the engine.

Extended Modelling

\[ Th_2 \xrightarrow{\eta} Th \xrightarrow{\text{diagnose}} \Delta^S \xrightarrow{\bar{\eta}} \Delta^S_{\bar{\varphi}} \]

1. Map sentences written in \( \mathcal{L} \) to a Horn clause theory \( Th \) using function \( \eta \)
   - For each \( q_j \) create a rule \( p_1 \land \ldots \land p_n \rightarrow q_j \).
   - For each \( q_1 \land \ldots \land q_{m,i} \) create a rule \( p_1 \land p_2 \land \ldots \land p_n \rightarrow q_1 \land \ldots \land q_{m,i} (p_j \in Hyp') \).
2. Compute the abductive diagnoses \( \Delta^S \) from \( Th \)
3. Convert the diagnoses to the original hypothesis space, i.e., \( \Delta^S_{\bar{\varphi}} \), using function \( \bar{\eta} \)
   - Remove non-minimal and inconsistent diagnoses
   - \( \Delta^S \) is not equivalent to the diagnoses on \( Th_{\bar{\varphi}} \), but more “intuitive”

Example:

\[ TH_2 = \{ \text{Tank_empty} \rightarrow \text{starter\_noise} \land \text{engine\_off}, \text{Engine\_broken} \rightarrow \text{starter\_noise} \land \text{engine\_off}, \text{Battery\_empty} \rightarrow \text{low\_charge} \lor \text{no\_charge}, \text{low\_charge} \rightarrow \text{starter\_noise} \land \text{engine\_off}, \text{no\_charge} \rightarrow \text{no\_starter\_noise} \land \text{engine\_off} \} \]

\[ \Delta^S_{\bar{\varphi}} = \{ \text{Tank\_empty}, \text{Engine\_broken}, \text{Battery\_empty} \} \]

REFERENCES