Knowledge Representation and Reasoning – Assignment I Model-based Diagnosis

1 Introduction

Model-based reasoning is one of the central topics of knowledge representation and reasoning in artificial intelligence. This first assignment of the course "Knowledge Representation and Reasoning" has the aim of increasing your understanding of various approaches to model-based reasoning through experimentation with systems or through implementation of algorithms.

For one of the two tasks described below, you need to provide a *brief* report that includes:

1. **a brief description of the task,**
2. **a description of the most important ideas underlying your solution,**
3. **a listing of a specification of a knowledge base or of the program that has been developed,**
4. **a number of tests showing that how you can exploit the reasoning method to solve the problem, or that the algorithm works.**

Your report needs to be submitted before *8th December, 2011*!

2 Select one of two tasks

The following sections offer descriptions of two tasks of which you need to *complete only one*, i.e., you *either* do Task I.1 or Task I.2.

2.1 Task I.1: Implementation of the hitting-set algorithm

The *hitting-set algorithm* acts as the core of consistency-based diagnosis, and has been extensively discussed during the course.

You need to carry out the following task:

(1) Develop a Prolog program of the hitting-set algorithm, using the description of the algorithm as given during the course. The input to the program is a set of sets; the output is the set of all *minimal* hitting sets (i.e. diagnoses), and

(2) Include some of the possible refinements to prune the search space as described in [6] (see blackboard or the library for the paper).

2.2 Task I.2: model-based reasoning with AILog

The *AILog* system is a Prolog program that supports *hypothetical reasoning*, i.e., reasoning on the basis of *assumptions*, also called assumables and abducibles. Theorist is a predecessor of this program [4]. Here there is a close resemblance between how AILog works and the theory of *abductive diagnosis* as discussed during the course.

At the URL `http://www.cs.ru.nl/~peterl/teaching/KeR/AILog` you can find a Prolog-implementation of the AILog system and a user manual [5]. The AILog system can be used as follows:

1. Start up SWI-Prolog
2. Load the AILog program into Prolog by entering `[ailog2].`
3. You can consult a knowledge base by entering
   `ailog: load <file>.`
4. Note that you have to enforce consistency in some cases by

   `create_nogoods.`

   (Figure out what this command does.)
5. Explanations of observations are obtained by `ask <logical formula>.`

The file `exmbr.ail` contains the example discussed during the course.

Now, consider the following knowledge that can be used as the basis for the construction of a *car repair advice system*:

A hole in the oil tank may cause leakage of oil below the car
A hole in the oil tank causes low oil level
A low level of oil and a running engine cause high temperature of the engine
A high temperature of the engine may cause a decrease in the power of the engine
A low engine power causes a decrease in acceleration of the car
Old spark plugs may cause irregular ignition
Irregular ignition causes a pinging engine
Irregular ignition may cause a decrease in engine power
A high engine temperature causes the temperature indicator to turn red

(1) Translate the knowledge given above concerning car repair into first-order logic, where logical implication $\leftarrow$ (or $\rightarrow$) is interpreted as a causal relation (do not forget to use incompleteness assumption literals);

(2) Represent the first-order logical knowledge base using the AILog syntax;

(3) Observable findings Φ are formulae that correspond to 'leakage of oil below the car', 'decrease in acceleration of the car' (this gives the formula Acceleration(*engine*, *decreased*)), ' pinging engine', and 'red temperature indicator';

(4) Now assume that the set of observed findings is equal to

$$F = \{\text{Acceleration}(\textit{engine}, \textit{decreased})\}.$$

Determine all possible diagnoses of this observation using AILog.

3 What to submit?

To summarise, you have to submit a brief report before 8th December, 2011 containing the following sections:

(1) A brief description of the task (I.1 or I.2) you chose.

(2) A description of the most important ideas behind your solution.

(3) Your solution in the form of Prolog or AILog code.

(4) At least three examples illustrating that the code works correctly.

Please submit the report on blackboard!

Referenties

[1] L. Console, D. Theseider Dupré and P. Torasso (1989). A theory of diagnosis for incomplete causal models. *Proceedings of the 10th International Joint Conference on Artificial Intelligence*, pp. 1311–1317.

[2] R. Greiber, B.A. Smith and R.W. Wilkerson (1989). A correction to the algorithm in Reiter's theory of diagnosis. *Artificial Intelligence*, **41**, 79–88.

[3] P.J.F. Lucas (1997). Symbolic diagnosis and its formalisation. *The Knowledge Engineering Review*, **12**(2), 109–146.

[4] D. Poole (1997). *A Theorist to Prolog Compiler*. Research Report, Department of Computer Science, University of British Columbia, Vancouver.

[5] D. Poole (2008). *AILog User Manual, version 2.3*. Research Report, Department of Computer Science, University of British Columbia, Vancouver.

[6] R. Reiter (1987). A theory of diagnosis from first principles. *Artificial Intelligence*, **32**, 57–95.