Foundations of Knowledge Representation
Nonmonotonic Reasoning I

Problem 1. *Consider Reiter's formalization of the closed world assumption (CWA):*

Let KB be a set of formulas, define a new form of entailment under CWA:

Denote $Negs = \{\neg p \mid p \text{ atomic and } KB \nvDash p\}$, *and define*

$KB \models_c \alpha$ *if and only if* $KB \cup Negs \models \alpha$

This is illustrated by the following example:

Example: $\{TramAt(05:22)\} \nvDash TramAt(05:46)$, *whence*
$\neg TramAt(05:46) \in Negs$, *and thus* $KB \models_c \neg TramAt(05:46)$

Do the following:

- *Provide an example where you illustrate that this new form of entailment is nonmonotonic.*
- *Assume* $KB \models (p \vee q)$, *but* $KB \nvDash p$ *and* $KB \nvDash q$. *Argue why this example is a problem for Reiter's formalization.*

Problem 2. *Assume that we learn about a bird, Tweety. We are convinced that Tweety flies unless we have information to the contrary.*

We know that (1) If a bird is not an abnormality it flies; and (2) A bird is an abnormality if and only if it is a penguin or an ostrich or injured or ...

Do the following:

- *Represent the sentences (1) and (2) in FOL.*
- *Note what problems we face using the FOL representation when we want to conclude that Tweety flies.*

Problem 3. *Consider the following defaults:*

(1) Quakers normally are pacifists.

(2) Republicans normally are not pacifists.

(3) Nixon is a quaker and a republican.

- *What is the problem here?*
- *Think of different approaches of how you could handle this problem.*

Problem 4. *The least Herbrand model M_P of a program P is the set of all ground atomic logical consequences of the program.*

Recall the Datalog knowledge base from exercise sheet 2: $\mathcal{K} = \langle \mathcal{R}, \mathcal{F} \rangle$ where $\mathcal{F}$ contains the following facts:

$$\mathcal{F} = \{\mathsf{Father}(john, mary), \mathsf{Mother}(mary, peter), \mathsf{Father}(john, david)\}$$

and $\mathcal{R}$ contains the following rules:

$$\mathsf{Parent}(x,y) \wedge \mathsf{Parent}(y,z) \rightarrow \mathsf{GrandParent}(x,z) \quad (1)$$
$$\mathsf{Parent}(x,y) \wedge \mathsf{Parent}(x,z) \rightarrow \mathsf{Sibling}(y,z) \quad (2)$$
$$\mathsf{Father}(x,y) \rightarrow \mathsf{Parent}(x,y) \quad (3)$$
$$\mathsf{Mother}(x,y) \rightarrow \mathsf{Parent}(x,y) \quad (4)$$

Compute the least Herbrand model of $\mathcal{K}$.

Note: Some of these problems are based on lecture slides by Hannes Straß and Gerhard Brewka.