SOLUTION NOTES

Artificial Intelligence II 2003 Paper 9 Question 8 (SBH)

1. Explain what the terms *ontological commitment* and *epistemological commitment* mean in the context of a language for knowledge representation and reasoning. What are the ontological and epistemological commitments made by propositional logic and by first order logic? [4 marks]

   Answer

   Ontological commitment is the commitment a language makes regarding what exists in the environment. For propositional logic this is that the environment consists of facts; for FOL that the environment consists of facts, relations, and objects.

   Epistemological commitment regards what may be believed about facts. For both propositional and FOL it is that they are true or false or unknown.

2. You wish to construct a robotic pet cat for the purposes of entertainment. One purpose of the cat is to scratch valuable objects when the owner is not present. Give a brief general description of *situation calculus* and describe how it might be used for knowledge representation by the robot. Include in your answer one example each of a *frame axiom*, an *effect axiom*, and a *successor-state axiom*, along with example definitions of suitable predicates and functions. [12 marks]

   Answer:

   The key idea is that the world moves sequentially from one *situation* to the next. Movement from one situation to another is caused by actions, and situations are regarded as part of the world being modelled using first-order logic.

   We therefore introduce in addition to predicates that describe parts of the world, a function called `result` such that `result(action,situation)` tells us the next situation; that is, the one we move into on account of performing the specified action in the specified situation.

   Anything that can change now has a situation argument. In this context we might use a predicate `at(location,thing,s)` to describe the whereabouts of the robot, the owner, items in the house and so on. For example:

   $$\texttt{at}(\texttt{l1}, \texttt{robot}, \texttt{s2}) \wedge \texttt{at}(\texttt{l3}, \texttt{owner}, \texttt{s2})$$

   denotes the fact that in situation `s2` the robot and owner are in different places. As the robot wants to scratch valuable items a predicate `valuable` might be used, so that we can specify `valuable(sofa)` and so on. If items are no longer valuable

after they are scratched however then `valuable` needs a situation argument. We probably also want to keep track of what's been scratched and this can change over time, so s predicate `scratched` is required with two arguments. For example `scratched(sofa,s3)`.

Effect axioms described the effects of actions. For example

$$\forall \mathtt{l}, \mathtt{i}, \mathtt{s}\ \mathtt{at}(\mathtt{l}, \mathtt{robot}, \mathtt{s}) \wedge \mathtt{at}(\mathtt{l}, \mathtt{i}, \mathtt{s}) \rightarrow \mathtt{scratched}(\mathtt{i}, \mathtt{result}(\mathtt{scratch}, \mathtt{s}))$$

Frame axioms describe what does not change. For example

$$\forall \mathtt{l}, \mathtt{s}, \mathtt{i}, \mathtt{a}\ \neg\mathtt{scratched}(\mathtt{i}, \mathtt{s}) \wedge (\mathtt{a} \neq \mathtt{scratch} \vee \neg(\mathtt{at}(\mathtt{l}, \mathtt{robot}, \mathtt{s}) \wedge \mathtt{at}(\mathtt{l}, \mathtt{i}, \mathtt{s}))) \rightarrow$$

$$\neg\mathtt{scratched}(\mathtt{i}, \mathtt{result}(\mathtt{a}, \mathtt{s}))$$

Successor-state axioms combine the two. For example

$$\forall \mathtt{i}, \mathtt{a}, \mathtt{s}, \mathtt{l}\ \mathtt{scratched}(\mathtt{i}, \mathtt{result}(\mathtt{a}, \mathtt{s})) \leftrightarrow (\mathtt{at}(\mathtt{l}, \mathtt{robot}, \mathtt{s}) \wedge \mathtt{at}(\mathtt{l}, \mathtt{i}, \mathtt{s})$$

$$\wedge \mathtt{a} = \mathtt{scratch}) \vee \mathtt{scratched}(\mathtt{i}, \mathtt{s})$$

3. Give a brief description of the *representational frame problem*, the *inferential frame problem*, the *qualification problem*, and the *ramification problem.* [4 marks]

Answer:

Representational frame problem: almost always, an action leaves almost everything in the world unchanged. However you still need a large number of frame axioms to describe this.

Inferential frame problem: if you move through a long sequence of situations then all properties have to be taken through the process even if they do not change.

Qualification problem: you can not in general specify exactly what is required to guarantee that some action will do what is expected.

Ramification problem: actions might have a very large number of consequences that you wish to avoid specifically modelling.