Two hours

UNIVERSITY OF MANCHESTER
SCHOOL OF COMPUTER SCIENCE

Dialogue Systems

Date: Wednesday 4th June 2008
Time: 09:45 – 11:45

Please answer Question One and TWO other Questions from the remaining four questions provided

This is a CLOSED book examination

The use of electronic calculators is NOT permitted.
1. **Compulsory**

   a) Outline the major components of a typical dialogue system. For each component, describe the objects that it takes as input and produces as output. (15 marks)

   b) Several of these components make use of background knowledge. Describe the role of background knowledge and inference in one of the components, and outline the design of a simple theorem prover for carrying out the required inference steps. (15 marks)

2. a) Describe how changing the shape of the vocal tract and tensing and relaxing the vocal cords enables people to produce a variety of distinguishable sounds. (10 marks)

   b) One of the following images shows the intensity (continuous wavy line) and pitch contours (short dotted line) for someone uttering the words *cab* and the other shows the same information for the same person saying *cap*. These images have been tightly cropped so that everything in the image is part of the word. Explain how a program might decide which of these images corresponded to which word. (15 marks)

   c) It is possible to generate speech by concatenating extracts of recorded utterances. What problems arise when you try to extract isolated phones, and how might extracting diphones improve the quality of the output? (10 marks)
3. a) Describe how a lexical trie can be used for storing a list of words. Show what a trie that contained the words *cat, cart, can, cane, cost, cool, cot, cotton* would look like. Explain why you can retrieve words more quickly from a trie than from a simple alphabetically ordered list, using the trie you have drawn to illustrate your explanation. (10 marks)

b) Use the notation of categorial morphology to show how the French adjectives *grand* (masculine singular), *grande* (feminine singular), *grands* (masculine plural), *grandes* (feminine plural) can be decomposed into a root, a number ending and a gender ending. Show how the cancellation rule $X/Z \Rightarrow X/Y,Y/Z$ can be used to provide a strictly left-to-right analysis of *grandes*. (15 marks)

c) When you add an affix to a root, there are often boundary effects on the written form, e.g. adding the past tense marker *-ed* to *can* produces *canned*, whereas the past tense form of *cane* is *caned*. Discuss the consequences of including rules that deal with these boundary effects on the simple lookup process used for looking words up in a lexical trie. (10 marks)
4. a) State the principle of compositionality, and discuss its significance for computational treatments of semantics. (7 marks)

b) Show the parse trees that the grammar below would assign to the sentence a girl saw a man with a big nose.

\[
\begin{align*}
v &\Rightarrow \text{np}, \text{vp} \\
v &\Rightarrow \text{vp}, \text{np} \\
v &\Rightarrow \text{vp}, \text{pp} \\
\text{np} &\Rightarrow \text{det}, \text{noun} \\
\text{noun} &\Rightarrow \text{adj}, \text{noun} \\
\text{noun} &\Rightarrow \text{noun}, \text{pp} \\
\text{pp} &\Rightarrow \text{prep}, \text{np} \\
\text{verb} &\Rightarrow \text{saw} \\
\text{noun} &\Rightarrow \text{girl} \\
\text{noun} &\Rightarrow \text{man} \\
\text{noun} &\Rightarrow \text{nose} \\
\text{adj} &\Rightarrow \text{big} \\
\text{det} &\Rightarrow \text{a} \\
\end{align*}
\]

How does the fact this sentence has multiple parse trees affect the validity of the principle of compositionality? (10 marks)

c) Suppose we added semantic annotations to the rule for making NPs and to the words \textit{a}, \textit{big} and \textit{nose} as follows:

\[
\begin{align*}
\text{np}(D;N) &\Rightarrow \text{det}(D), \text{noun}(N) \\
\text{noun}(\lambda(X, \text{nose}(X))) &\Rightarrow \text{nose} \\
\text{adj}(\lambda(Y, \text{big}(Y))) &\Rightarrow \text{big} \\
\text{det}(\lambda(P, \lambda(Q, \exists(R::\{P::R\}, Q::R))) &\Rightarrow \text{a} \\
\end{align*}
\]

Show how this would lead to the formula \[\lambda(Q, \exists(R::\{\text{nose}(R)\}, Q::R))\] as the interpretation of \textit{a nose}. Suggest an annotation for the rule \text{noun} \Rightarrow \text{adj}, \text{noun} which would produce \[\lambda(Q, \exists(R::\{\text{nose}(R) \& \text{big}(R)\}, Q::R))\] as the interpretation of \textit{a big nose}. (18 marks)
5. a) Describe how the idea of ‘indirect speech acts’ can be used to explain why just saying ‘Yes’ is not normally seen as a satisfactory response to the question ‘Do you know the time?’. (8 marks)

b) Give STRIPS-like characterisations of the actions of INFORM and NAG which would enable you to tell whether someone who said ‘You haven’t done the washing up’ was informing or nagging their hearer, and show why in most situations this utterance would be an instance of nagging. (15 marks)

c) Explain the role of a record of what has been said (often referred to as the ‘minutes’) in dialogue processing, with particular reference to the analysis of referring expressions. (12 marks)