Two hours

UNIVERSITY OF MANCHESTER
SCHOOL OF COMPUTER SCIENCE

Dialogue Systems

Date: Tuesday 8th June 2010
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) Describe the major components of a typical dialogue system, and describe the dataflow between these components. (8 marks)

   b) Describe two examples of decisions that have to be made early in the interpretation of an input utterance but which depend on information that will only be available later on. (4 marks)

   c) i) Explain either how using minimal descriptors in referential expressions helps participants in a discourse verify that they have similar views of what the discourse is about. (8 marks)

       or

       ii) how merging the application of spelling rules and traversal of a lexical trie provides a more efficient approach to lexical lookup than carrying out these two activities separately. (8 marks)
2. a) Describe what a hidden Markov model (HMM) does, and explain why HMMs are widely used in speech recognition systems. (12 marks)

b) Given the speech signal in Fig 2 show how the HMM in Fig 1 could be used to determine whether the speaker said ‘bite’ or ‘eat’. (8 marks)

![Figure 1: Simple HMM for ‘bite’ and ‘eat’](image1)

![Figure 2: Speech signal for ‘bite’ or ‘eat’](image2)
3. a) Given the grammar and lexicon below, construct a categorial description of the words in the lexicon that has the same coverage and produces the same parse trees. 

\[
\begin{align*}
  s & \mapsto [np, vp]. & \text{word(he, np)}. \\
  np & \mapsto [\text{det}, \text{nn}]. & \text{word(runs, iverb)}. \\
  nn & \mapsto [\text{adj}, \text{nn}]. & \text{word(runs, tverb)}. \\
  vp & \mapsto [\text{iverb}]. & \text{word(a, det)}. \\
  vp & \mapsto [\text{tverb}, np]. & \text{word(smaller, adj)}. \\
 & & \text{word(business, nn)}. 
\end{align*}
\]

b) Describe how a chart parser works. 

c) Show the edges that a left-corner chart parser would produce when using the context-free grammar from part (a) (NOT your categorial version) to analyse the sentence ‘He runs a small business’.

4. a) What is an ‘indirect speech act’? Explain informally how indirect speech acts can be used to account for the reply ‘I’m sorry, my car broke down’ when asked the question ‘Do you know the time?’.

b) Consider the STRIPS-style representations of the actions inform and nag below, where \(\text{bel}(X, P)\) means ‘X believes P’ and ‘\(\text{mut}(X, Y, P)\)’ means ‘X and Y are mutually aware of P’.

\[
\begin{align*}
  \text{nag}(X, Y, P): & \\
  & \text{pre: \text{bel}(X, P), \text{bel}(X, \text{bel}(Y, P))} \\
  & \text{effects: \text{mut}(X, Y, P)} \\
  \text{inform}(X, Y, P): & \\
  & \text{pre: \text{bel}(X, P), \text{bel}(X, \text{not}(\text{bel}(Y, P)))} \\
  & \text{effects: \text{mut}(X, Y, P)} 
\end{align*}
\]

Explain how these two actions can be used to achieve different outcomes even though their stated effects are the same, and explain how the stated effects can be derived from recognition of the fact that the given actions were performed.
5. a) Describe the role of ‘logical forms’ in natural language understanding systems, and discuss the importance of entailment and ambiguity in the evaluation of theories of meaning. (8 marks)

b) Given the grammar and lexicon below, find the logical forms for (a) ‘A man ran’ and (b) ‘A human moved’. (6 marks)

c) Write meaning postulates that would enable you to show that (a) entails (b). (6 marks)

\[
\begin{align*}
S & \rightarrow [NP, VP] : - \\
S & \leftarrow s, \\
NP & \leftarrow np, \\
VP & \leftarrow vp, \\
\text{meaning}@S & \leftarrow \text{meaning}@VP: \text{meaning}@NP.
\end{align*}
\]

\[
\begin{align*}
NP & \rightarrow [DET, NOUN] : - \\
NP & \leftarrow np, \\
NOUN & \leftarrow noun, \\
DET & \leftarrow det, \\
\text{meaning}@NP & \leftarrow \text{meaning}@DET: \text{meaning}@NOUN.
\end{align*}
\]

\[
\begin{align*}
\text{word}(moved, X) : - \\
X & \leftarrow vp, \\
\text{meaning}@X & \leftarrow \lambda(A, \\
& \quad \exists(B, \\
& \quad \text{move}(B) \\
& \quad \& A: \lambda(U, \text{agent}(C, U))))).
\end{align*}
\]

\[
\begin{align*}
\text{word}(ran, X) : - \\
X & \leftarrow vp, \\
\text{meaning}@X & \leftarrow \lambda(A, \\
& \quad \exists(B, \\
& \quad \text{run}(B) \\
& \quad \& A: \lambda(U, \text{agent}(C, U))))).
\end{align*}
\]

\[
\begin{align*}
\text{word}(a, X) : - \\
X & \leftarrow det, \\
\text{meaning}@X & \leftarrow \lambda(K, \lambda(L, \exists(M, (K:M) \& (L:M))))).
\end{align*}
\]

\[
\begin{align*}
\text{word}(human, X) : - \\
X & \leftarrow noun, \\
\text{meaning}@X & \leftarrow \lambda(T, \text{human}(T)).
\end{align*}
\]

\[
\begin{align*}
\text{word}(man, X) : - \\
X & \leftarrow noun, \\
\text{meaning}@X & \leftarrow \lambda(V, \text{man}(V)).
\end{align*}
\]

END OF EXAMINATION