Advanced AI Techniques (WS04)

Exercise sheet 7

Deadline: Thursday, 9 Dec 04

Exercise 1 (2 points)

1. *Is the following set of probabilistic rules a PCFG? Why or why not?*

   Terminals: $\{you, this, can, see, read, and, should\}$
   Nonterminals: $\{S, \quad AUX, \quad NP, \quad VP, \quad C, \quad V\}$
   Start symbol: S
   Rules and Probabilities:
   $S \quad \rightarrow \quad NP \quad VP \quad (0.5)$
   $S \quad \rightarrow \quad AUX \quad NP \quad VP \quad (0.2)$
   $S \quad \rightarrow \quad NP \quad AUX \quad VP \quad (0.3)$
   $VP \quad \rightarrow \quad V \quad NP \quad (1.0)$
   $NP \quad \rightarrow \quad NP \quad (0.8)$
   $NP \quad \rightarrow \quad NP \quad C \quad NP \quad (0.2)$
   $NP \quad \rightarrow \quad you \quad (0.6)$
   $NP \quad \rightarrow \quad this \quad (0.4)$
   $AUX \quad \rightarrow \quad can \quad (0.7)$
   $AUX \quad \rightarrow \quad should \quad (0.3)$
   $V \quad \rightarrow \quad see \quad (0.9)$
   $V \quad \rightarrow \quad read \quad (0.1)$
   $C \quad \rightarrow \quad and \quad (1.0)$

2. *Find a PCFG in CNF that can generate the same sentences.*

In correspondence with forward and backward probabilities in HMMs
Forward probability $\alpha_i(t) = P(w_{1(t-1)}, X_t = i)$
Backward probability $\beta_i(t) = P(w_{tT}|X_t = i)$,
we defined similar concepts for the more general case of PCFGs:
Outside probability $\alpha_j(p,q) = P(w_{1(p-1)}, N^j_{pq}, w_{(q+1)m}|G)$
Inside probability $\beta_j(p,q) = P(w_{pq}|N^j_{pq}, G)$.

The inside probabilitiy $\beta_j(p,q)$ is the total probability of generating words $w_p \ldots w_q$ given that one is starting off with the nonterminal N_j. The outside probability $\alpha_j(p,q)$ is the total probabilty of beginning with the start symbol N^1 and generating the nonterminal N^j_{pq} and all the words outside $w_p \ldots w_q$.
In the next two exercises, you use these probabilities.

Exercise 2 (4 points)

Using a parse triangle like in the lecture slide 137, calculate the outside probabilities for the sentence

astronomers saw stars with ears

according to the simple PCFG introduced in the lecture (slide 121). Start at the top righthand corner and work towards the diagonal.

Exercise 3 (6 points)

1. *Using the inside and outside probabilities for the sentence*

   astronomers saw stars with ears

   worked out in the lecture and in the previous exercise, reestimate the probabilities of the simple PCFG (slide 121) by working through one iteration of the Inside-Outside algorithm. It is helpful to first link up the inside probabilities shown in slide 137 with the particular rules and subtrees used to obtain them.

2. *What would the rule probabilities converge to with continued iterations of the Inside-Outside algorithm? why?*