Advanced AI Techniques (WS05)

Excercise sheet 6

Deadline: 20.12.05

Excercise 1 (2 points)

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

Terminals: {you, this, can, see, read, and, should}
Nonterminals: {S, AUX, NP, VP, C, V}
Start Symbol: S

Rules and Probabilities:
S → NP VP (0.5)
S → AUX NP VP (0.2)
S → NP AUX VP (0.3)
VP → V NP (1.0)
NP → NP (0.8)
NP → NP C NP (0.2)
NP → you (0.6)
NP → this (0.4)
AUX → can (0.7)
AUX → should (0.3)
V → see (0.9)
V → read (0.1)
C → and (1.0)

b.) Find a PCFG in CNF that can generate the same sentences.

Excercise 2 (6 points)

In correspondance 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 $\beta(p,q) = P(w_{pq}|N^j_{pq}, G)$

The inside probability $\beta_j(p,q)$ is the total probability of generating words $w_p, ..., w_q$ given that one is starting off with the nonterminal N_j. The outside probability $\alpha_j(p,q)$ is the total probability of beginning with the start symbol N^1 and generating the nonterminal N^j_{pq} and all the words outside $w_p, ..., w_q$.
Using a parsing triangle like in the lecture slide 143, 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 upper righthand corner and work towards the diagonal. You may, of course, use the β-values already calculated in the lecture (Table on slide 141).

Excercise 3 (4 points)

Consider the following Probabilistic Definite Clause Grammar:

$0.4 : S(X) \rightarrow P(X), P(X)$
$0.6 : S(X) \rightarrow Q(X)$
$0.3 : P(a) \rightarrow a$
$0.7 : P(b) \rightarrow b$
$0.2 : Q(a) \rightarrow a$
$0.8 : Q(b) \rightarrow b$

and the sentence s="aa".

a.) Find a derivation der in G for the non-terminal $S(X)$ that yields the sentence s.

*b.) Compute the **derivation** probability $P_D(der|G)$.*

*c.) Compute the **refutation** probability $P_R(der|G)$.*

*d.) Compute the **sentence** probability $P_S(s|G)$.*