

Q.1 (5+1=6 marks)

a) Draw the top-ranked parse tree for the sentence below by applying the PCFG given in below table. Does the results are good? Provide your comments.

Sentence: Write the notebooks with pencil.

Consider the following PCFG

| | |
|--|-----|
| $S \rightarrow VP$ | 1.0 |
| $VP \rightarrow \text{Verb NP}$ | 0.7 |
| $VP \rightarrow \text{Verb NP PP}$ | 0.3 |
| $NP \rightarrow \text{NP PP}$ | 0.3 |
| $NP \rightarrow \text{Det Noun}$ | 0.7 |
| $PP \rightarrow \text{Prep Noun}$ | 1.0 |
| $\text{Det} \rightarrow \text{the}$ | 0.1 |
| $\text{Verb} \rightarrow \text{Write} \mid \text{Ask} \mid \text{Find} \mid \dots$ | 0.1 |
| $\text{Prep} \rightarrow \text{with} \mid \text{in} \mid \dots$ | 0.1 |
| $\text{Noun} \rightarrow \text{notebooks} \mid \text{teacher} \mid \text{pencil} \mid \text{college} \mid \text{bike} \mid \text{summer} \mid \dots$ | 0.1 |

Soln

first tree

(i)

$S(1.0) \rightarrow VP(0.7) \rightarrow \text{Verb}(0.1) \text{ write} \text{ NP}(0.3) \rightarrow \text{NP}(0.7) \text{ PP}(1.0)$
 $\text{NP}(0.7) \rightarrow \text{det}(0.1) \text{ the} \text{ NP}(0.1) \text{ notebooks} \text{ PP}(0.7) \text{ with} \text{ Noun}(0.1) \text{ pencil}$

probability of this parse tree = $1 \times 0.7 \times 0.3 \times 0.1 \times 0.7 \times 0.1 \times 0.1 \times 0.1 \times 0.1$
 $= 0.7 \times 0.3 \times 0.7 \times (0.1)^5$

2nd tree

(ii) (best parse tree)

$S(1.0) \rightarrow VP(0.3) \rightarrow \text{Verb}(0.1) \text{ write} \text{ PP}(0.7) \text{ NP}(1.0)$
 $\text{PP}(0.7) \rightarrow \text{prep}(0.1) \text{ with} \text{ NP}(0.7) \text{ the} \text{ NP}(0.1) \text{ notebooks}$

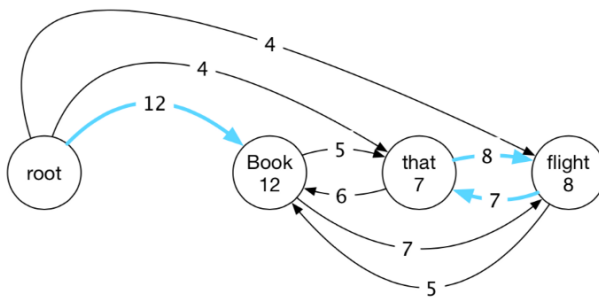
prob. of this parse tree = $1 \times 0.3 \times 0.7 \times 1 \times (0.1)^5$

2nd parse tree is the best parse tree because its probability is more.

b) Which of the three Noun Phrases (1. Pronoun, 2. Proper Noun, 3. Common Noun) to be the most difficult to handle computationally while performing top-down parsing. Explain why?

Q2. (6+2=8 marks)

a). Does the following stage of a Edmond algorithm parsing has an MST ? If not, continue the algorithm for one more step with an Explanation. Obtain MST.



Q2 Ans is No. Because there is a cycle b/w words that & flight. To remove the cycle & get an MST for each node Book, that, flight we select the edge having the max. weight.

now we club the vertices that & flight into one vertex.

Now we have to select the incoming vertex do this combined vertex

incoming are to cycle

max (root \rightarrow that \rightarrow flight, root \rightarrow flight \rightarrow that)
 $= \max(4+8, 4+7) = 12$ (that \rightarrow flight)

max (Book \rightarrow that \rightarrow flight, Book \rightarrow flight \rightarrow that)
 $= \max(5+8, 7+7) = 14$ (flight \rightarrow that)

Outgoing are
 $\max(\text{flight} \rightarrow \text{book}, \text{that} \rightarrow \text{book}) = \max(5, 6) = 6$.

Now we connect every pair of vertices

now we select for each vertex max incoming are

root \rightarrow book \rightarrow that \rightarrow flight

There is no cycle. MST ends here

final MST (Soln)

b) What are the basic differences between syntactic parsing and dependency parsing.

Ans: See from the slides

Q3 (6+2=8 marks)

a) Given, the following training corpus, Using a bigram language model with and without add-one smoothing, what is $P(\text{Delhi is beautiful})$?

<s> Delhi is the capital of India </s>

<s> Delhi is cold </s>

<s> Delhi has beautiful gardens </s>

Solution:

$$P(\text{Delhi is beautiful}) = P(\text{Delhi} | <s>) * P(\text{is} | \text{Delhi}) * P(\text{beautiful} | \text{is}) * P(</s> | \text{beautiful})$$

$$P(w_n | w_{n-1}) = C(w_{n-1} w_n) / C(w_{n-1})$$

Without Smoothing

$$P(\text{Delhi} | <s>) = 3/3 = 1$$

$$P(\text{is} | \text{Delhi}) = 2/3 = 0.676$$

$$P(\text{beautiful} | \text{is}) = 0/2 = 0$$

$$P(</s> | \text{beautiful}) = 0/1 = 0$$

Unique words = 10

With Smoothing

$$P(\text{Delhi} | <s>) = (3+1)/(3+10) = 0.31$$

$$P(\text{is} | \text{Delhi}) = (2+1)/(3+10) = 0.23$$

$$P(\text{beautiful} | \text{is}) = (0+1)/(2+10) = 0.08$$

$$P(</s> | \text{beautiful}) = (0+1)/(1+10) = 0.09$$

$$P(\text{Delhi is beautiful}) = 0.31 * 0.23 * 0.08 * 0.09 = 5.13 * 10^{-4}$$

b) Suppose the sentence consists of random alphabets (A, a, B, b, ..., Z, z) and each of the 26 letters in upper and lower case occurs with equal probability. What is the perplexity of this sentence?

$$PP(W) = P(w_1 w_2 \dots w_N)^{-1/N}$$

Since both upper and lower cases are considered 52 letters have equal probability.

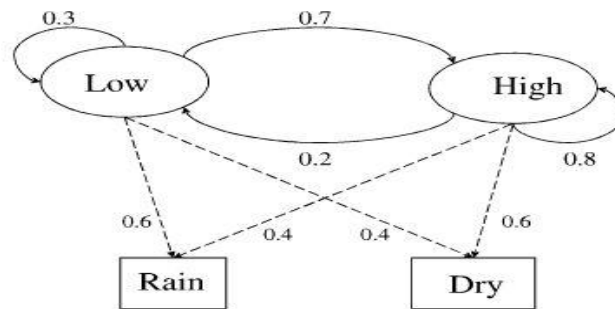
$$\text{Perplexity is } \left(\left(\frac{1}{52} \right)^{52} \right)^{-1/52}$$

$$= 52$$

Q4. (3+5=8 marks)

The following diagram describes HMM model with two hidden states: Low and High

and the observations are rainy and dry. Both the states are equally probable to be initial states



- Construct transition state matrix and emission matrix.
- Let the observation sequence be given as Dry, Rain. Give the corresponding Hidden state sequence.

Ans 4 (a)

Transition matrix

| | Low | High |
|------|-----|------|
| Low | 0.3 | 0.7 |
| High | 0.2 | 0.8 |

Emission matrix

| | Rainy | Dry |
|------|-------|-----|
| Low | 0.6 | 0.4 |
| High | 0.4 | 0.6 |

(b) Observation sequence is Dry, Rain
 Hidden state could be Low Low, Low High, High Low, High High

Low $0.5 \times 0.4 = 0.2$ $\max \begin{cases} 0.2 \times 0.3 \times 0.6 & (L) \\ 0.3 \times 0.2 \times 0.6 & (H) \end{cases}$ Low

High $0.5 \times 0.6 = 0.3$ $\max \begin{cases} 0.7 \times 0.2 \times 0.4 & (L) \\ 0.8 \times 0.3 \times 0.4 & (H) \end{cases}$ High

Dry Rain

Ans High High