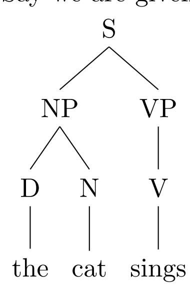
1 Basics of PCFGs (Part 1)

1.1 Question (time: 6:42, slide: 4)

Consider the following PCFG

$q(\text{S} \rightarrow \text{NP VP}) = 0.9$ $q(\text{S} \rightarrow \text{NP}) = 0.1$ $q(\text{NP} \rightarrow \text{D N}) = 1$ $q(\text{VP} \rightarrow \text{V}) = 1$
$q(\text{D} \rightarrow \text{the}) = 0.8$ $q(\text{D} \rightarrow \text{a}) = 0.2$ $q(\text{N} \rightarrow \text{cat}) = 0.5$ $q(\text{N} \rightarrow \text{dog}) = 0.5$
$q(\text{V} \rightarrow \text{sings}) = 1$

Say we are given a parse tree



What is the probability of this parse?

1.2 Question (time: 9:42, slide: 5)

Consider the following PCFG with start symbol "S"

$q(\text{S} \rightarrow \text{NP VP}) = 1.0$ $q(\text{VP} \rightarrow \text{VP PP}) = 0.9$ $q(\text{VP} \rightarrow \text{V NP}) = 0.1$
$q(\text{NP} \rightarrow \text{NP PP}) = 0.5$ $q(\text{NP} \rightarrow \text{N}) = 0.5$ $q(\text{PP} \rightarrow \text{P NP}) = 1.0$
$q(\text{N} \rightarrow \text{Ted}) = 0.2$ $q(\text{N} \rightarrow \text{Jill}) = 0.2$ $q(\text{N} \rightarrow \text{town}) = 0.6$
$q(\text{V} \rightarrow \text{saw}) = 1.0$ $q(\text{P} \rightarrow \text{in}) = 1.0$

Say we are given the sentence

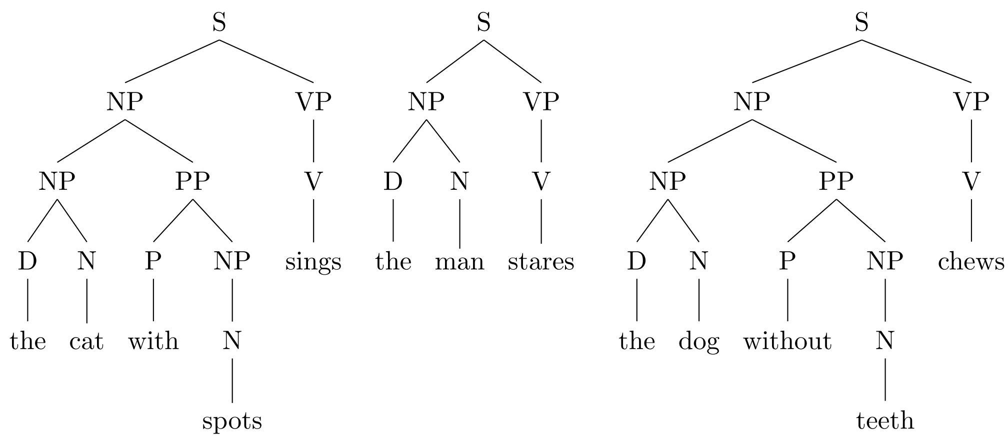
- Ted saw Jill in town.

What is the highest probability for any parse tree under this PCFG?

2 Basics of PCFGs (Part 2)

2.1 Question (time: 4:06, slide: 7)

Consider the following treebank



If we compute the maximum-likelihood PCFG from this treebank, what is the value of $q_{\mathrm{ML}}(\mathrm{NP} \rightarrow \mathrm{NP\ PP})$ to three decimal places?

3 The CKY Parsing Algorithm (Part 1)

3.1 Question (time: 7:31, slide: 10)

Consider the following PCFG not in Chomsky normal form

$q(\mathrm{S} \rightarrow \mathrm{N\ VP}) = 0.5$	$q(\mathrm{VP} \rightarrow \mathrm{V\ N}) = 0.6$
$q(\mathrm{VP} \rightarrow \mathrm{V\ N\ PP}) = 0.4$	$q(\mathrm{PP} \rightarrow \mathrm{P\ N}) = 1.0$
$q(\mathrm{N} \rightarrow \mathrm{dog}) = 1.0$	$q(\mathrm{P} \rightarrow \mathrm{in}) = 1.0$
$q(\mathrm{V} \rightarrow \mathrm{saw}) = 1.0$	

We then convert to Chomsky normal form by changing the rules to

S $\rightarrow$ N VP	VP $\rightarrow$ V N
VP $\rightarrow$ V N/PP	N/PP $\rightarrow$ N PP
PP $\rightarrow$ P N	N $\rightarrow$ dog
P $\rightarrow$ in	V $\rightarrow$ saw

If we want the new PCFG to be equivalent to the old PCFG and we are told $q(\mathrm{N/PP} \rightarrow \mathrm{N\ PP}) = 1.0$, what should be the value of $q(\mathrm{VP} \rightarrow \mathrm{V\ N/P})$?

4 The CKY Parsing Algorithm (Part 2)

4.1 Question (time: 5:05, slide: 12)

Consider the sentence from the previous slide

- the dog saw the man with the telescope

Say we are given a PCFG with the rules

- $q(\mathrm{NP} \rightarrow \mathrm{D\ N}) = 0.5$
- $q(\mathrm{NP} \rightarrow \mathrm{N}) = 0.5$

- $q(\mathrm{D} \rightarrow \mathrm{the}) = 1.0$
- $q(\mathrm{N} \rightarrow \mathrm{dog}) = 0.1$
- $q(\mathrm{N} \rightarrow \mathrm{cat}) = 0.9$

What is the value for $\pi(1, 2, \mathrm{NP})$?

4.2 Question (time: 13:21, slide: 14)

Consider the sentence from the previous slide

- the dog saw the man with the telescope

Assume that we have π values such that

$\pi(3, 3, \mathrm{V}) \times \pi(4, 8, \mathrm{NP}) = 0.01 \quad \pi(3, 5, \mathrm{VP}) \times \pi(6, 8, \mathrm{PP}) = 0.1$
$\pi(3, 6, \mathrm{VP}) \times \pi(7, 8, \mathrm{NP}) = 0.1 \quad \pi(3, 7, \mathrm{VP}) \times \pi(8, 8, \mathrm{N}) = 0.01$

- For all other values of $s \in \{3 \ldots 7\}$ and $X \in N, Y \in N$, assume that $\pi(3, s, Y) \times \pi(s + 1, 8, X) = 0$

Also assume that the PCFG has the following parameters

$q(\mathrm{VP} \rightarrow \mathrm{V\ NP}) = 0.2 \quad q(\mathrm{VP} \rightarrow \mathrm{VP\ PP}) = 0.5$
$q(\mathrm{VP} \rightarrow \mathrm{VP\ NP}) = 0.2 \quad q(\mathrm{VP} \rightarrow \mathrm{VP\ N}) = 0.1$

What is the value for $\pi(3, 8, \mathrm{VP})$?

A Answers

- 0.36

  The answer is 0.36, which is the product of the rules used in the tree.

- 0.00027

  There are two possible parse trees for this sentence, one attaches the preposition to the verb "saw" and the other attaches it to the noun "Jill". The verbal attachment has higher probability which is 0.00027.

- 0.286

  The non-terminal NP is seen seven times. Two times it has NP PP as children, so the correct value rounds to 0.286.

- 0.4

  The rule VP $\rightarrow$ V N/PP is the CNF form of the rule VP $\rightarrow$ V N PP, so it should have the same value as the original rule, 0.4, after the conversion.

- 0.05

  There is only one parse of the first two words of the sentence. Its value is $q(\text{D} \rightarrow \text{the}) \times q(\text{N} \rightarrow \text{dog}) \times q(\text{NP} \rightarrow \text{D N}) = 0.05$.

- 0.05

  The highest scoring of the four rules is VP $\rightarrow$ VP PP. Its score is $\pi(3, 5, \text{VP}) \times \pi(6, 8, \text{PP}) \times q(\text{VP} \rightarrow \text{VP PP}) = 0.05$.