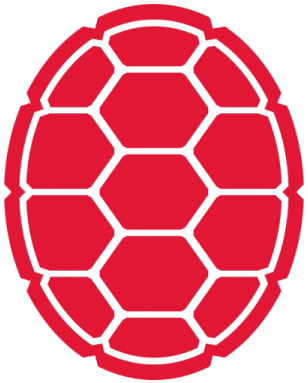


Constituency Parsing

Computational Linguistics: Jordan Boyd-Graber
University of Maryland
EXERCISE

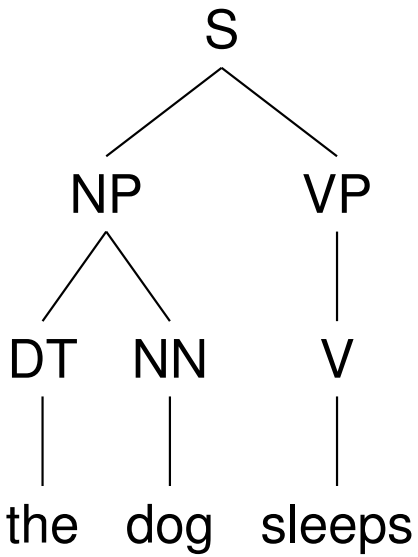
A pcfg

Assume the following grammar

s	→	np	vp	1.0	v	→	sleeps	0.4
vp	→	v	np	0.7	v	→	saw	0.6
vp	→	vp	pp	0.2	nn	→	man	0.1
vp	→	v		0.1	nn	→	woman	0.1
np	→	dt	nn	0.2	nn	→	telescope	0.3
np	→	np	pp	0.8	nn	→	dog	0.5
pp	→	p	np	1.0	dt	→	the	1.0
					p	→	with	0.6
					p	→	in	0.4

Evaluating the probability of a sentence

What is the probability of the parse



Evaluating the probability of a sentence

$$\underbrace{1.0}_{\text{det} \rightarrow \text{the}} \cdot \underbrace{0.5}_{\text{n} \rightarrow \text{dog}} \cdot \underbrace{0.4}_{\text{v} \rightarrow \text{sleeps}} \cdot \underbrace{0.1}_{\text{vp} \rightarrow \text{v}} \cdot \underbrace{0.2}_{\text{np} \rightarrow \text{dt n}} \cdot \underbrace{1.0}_{\text{s} \rightarrow \text{np vp}} = 0.004$$

Parsing Sentence

What's the best parse for the sentence

1	2	3	4	5	6	7	8
the	man	saw	the	dog	with	a	telescope

Under the grammar

s	→	np	vp	1.0	v	→	sleeps	0.4
vp	→	v	np	0.7	v	→	saw	0.6
vp	→	vp	pp	0.2	nn	→	man	0.1
vp	→	v		0.1	nn	→	woman	0.1
np	→	dt	nn	0.2	nn	→	telescope	0.3
np	→	np	pp	0.8	nn	→	dog	0.5
pp	→	p	np	1.0	dt	→	the	1.0
					p	→	with	0.6
					p	→	in	0.4

First, do spans for single word (e.g., $C[8, 8, \text{nn}]$.

Span 0

1. $C[8, 8, \text{nn}] = \ln(0.3) = -1.2$
2. $C[7, 7, \text{dt}] = \ln(1.0) = 0.0$
3. $C[6, 6, \text{p}] = \ln(0.6) = -0.51$
4. $C[5, 5, \text{nn}] = \ln(0.5) = -0.69$
5. $C[4, 4, \text{dt}] = \ln(1.0) = 0.0$
6. $C[3, 3, \text{v}] = \ln(0.6) = -.51$
7. $C[3, 3, \text{vp}] = \ln(0.6) + \ln(0.1) = -2.8$
8. $C[2, 2, \text{nn}] = \ln(0.1) = -2.3$
9. $C[1, 1, \text{dt}] = \ln(1.0) = 0.0$

Span 1

1. $C[1,2,\text{np}] = \underbrace{0.0}_{\text{C[1,1,DT]}} + \underbrace{-2.3}_{\text{C[2,2,NN]}} + \ln(\underbrace{0.2}_{\text{np} \rightarrow \text{dt n}}) = -2.3 + -1.6 = -3.9$

Span 1

1. $C[1,2,\text{np}] = \underbrace{0.0}_{\text{C[1,1,DT]}} + \underbrace{-2.3}_{\text{C[2,2,NN]}} + \ln(\underbrace{0.2}_{\text{np} \rightarrow \text{dt n}}) = -2.3 + -1.6 = -3.9$

2. $C[4,5,\text{np}] = \underbrace{0.0}_{\text{C[4,4,DT]}} + \underbrace{-.69}_{\text{C[5,5,NN]}} + \ln(\underbrace{0.2}_{\text{np} \rightarrow \text{dt n}}) = -0.69 + -1.6 = -2.3$

Span 1

1. $C[1,2,\text{np}] = \underbrace{0.0}_{\text{C[1,1,DT]}} + \underbrace{-2.3}_{\text{C[2,2,NN]}} + \ln(\underbrace{0.2}_{\text{np} \rightarrow \text{dt n}}) = -2.3 + -1.6 = -3.9$

2. $C[4,5,\text{np}] = \underbrace{0.0}_{\text{C[4,4,DT]}} + \underbrace{-.69}_{\text{C[5,5,NN]}} + \ln(\underbrace{0.2}_{\text{np} \rightarrow \text{dt n}}) = -0.69 + -1.6 = -2.3$

3. $C[7,8,\text{np}] = \underbrace{0.0}_{\text{C[7,7,DT]}} + \underbrace{-1.2}_{\text{C[8,8,NN]}} + \ln(\underbrace{0.2}_{\text{np} \rightarrow \text{dt n}}) = -1.2 + -1.6 = -2.8$

Span 2

1. $C[1,3,\text{s}] = \underbrace{-3.9}_{\text{C[1,2,NP]}} + \underbrace{-2.8}_{\text{C[3,3,VP]}} + \ln(\underbrace{1.0}_{\text{s} \rightarrow \text{np vp}}) = -6.7$

Span 2

1. $C[1,3,\text{s}] = \underbrace{-3.9}_{\text{C[1,2,NP]}} + \underbrace{-2.8}_{\text{C[3,3,VP]}} + \ln(\underbrace{1.0}_{\text{s} \rightarrow \text{np vp}}) = -6.7$
2. $C[3,5,\text{vp}] = \underbrace{-0.5}_{\text{C[3,3,V]}} + \underbrace{-2.3}_{\text{C[4,5,NP]}} + \ln(\underbrace{0.7}_{\text{vp} \rightarrow \text{v np}}) = -2.8 - 0.36 = -3.2$

Span 2

1. $C[1,3,s] = \underbrace{-3.9}_{\text{C[1,2,NP]}} + \underbrace{-2.8}_{\text{C[3,3,VP]}} + \ln(\underbrace{1.0}_{\text{s} \rightarrow \text{np vp}}) = -6.7$
2. $C[3,5,vp] = \underbrace{-0.5}_{\text{C[3,3,V]}} + \underbrace{-2.3}_{\text{C[4,5,NP]}} + \ln(\underbrace{0.7}_{\text{vp} \rightarrow \text{v np}}) = -2.8 - 0.36 = -3.2$
3. $C[6,8,pp] = \underbrace{-0.51}_{\text{C[6,6,P]}} + \underbrace{-2.8}_{\text{C[7,8,NP]}} + \ln(\underbrace{1.0}_{\text{pp} \rightarrow \text{p np}}) = -3.3 + -1.6 = -3.3$

Span 4

1. $C[1,5,\text{s}] = \underbrace{-3.9}_{\text{C[1,2,NP]}} + \underbrace{-3.2}_{\text{C[3,5,VP]}} + \ln(\underbrace{1.0}_{\text{s} \rightarrow \text{np vp}}) = -7.1$

Span 4

1. $C[1,5,\text{s}] = \underbrace{-3.9}_{\text{C[1,2,NP]}} + \underbrace{-3.2}_{\text{C[3,5,VP]}} + \ln(\underbrace{1.0}_{\text{s} \rightarrow \text{np vp}}) = -7.1$
2. $C[4,8,\text{np}] = \underbrace{-2.3}_{\text{C[4,5,NP]}} + \underbrace{-3.3}_{\text{C[6,8,PP]}} + \ln(\underbrace{0.8}_{\text{np} \rightarrow \text{np pp}}) = -5.6 + -0.2 = -5.8$

Span 5

$$C[3,8,\text{vp}] = \max(\tag{1}$$

$$\underbrace{-3.2}_{\text{C[3,5,VP]}} + \underbrace{-3.3}_{\text{C[6,8,PP]}} + \underbrace{-1.6}_{\text{vp} \rightarrow \text{vp pp}}, \tag{2}$$

$$\underbrace{-0.5}_{\text{C[3,3,V]}} + \underbrace{-5.8}_{\text{C[4,8,NP]}} + \underbrace{-.36}_{\text{vp} \rightarrow \text{v np}}) \tag{3}$$

$$= \max(-8.1, -6.7) = -6.7 \tag{4}$$

Span 5

$$C[3,8,\text{vp}] = \max(\tag{1}$$

$$\underbrace{-3.2}_{\text{C[3,5,VP]}} + \underbrace{-3.3}_{\text{C[6,8,PP]}} + \underbrace{-1.6}_{\text{vp} \rightarrow \text{vp pp}}, \tag{2}$$

$$\underbrace{-0.5}_{\text{C[3,3,V]}} + \underbrace{-5.8}_{\text{C[4,8,NP]}} + \underbrace{-.36}_{\text{vp} \rightarrow \text{v np}}) \tag{3}$$

$$= \max(-8.1, -6.7) = -6.7 \tag{4}$$

Which is it? “dog through telescope” or “dog holding telescope”?

Span 5

$$C[3,8,\text{vp}] = \max(\tag{1}$$

$$\underbrace{-3.2}_{\text{C[3,5,VP]}} + \underbrace{-3.3}_{\text{C[6,8,PP]}} + \underbrace{-1.6}_{\text{vp} \rightarrow \text{vp pp}}, \tag{2}$$

$$\underbrace{-0.5}_{\text{C[3,3,V]}} + \underbrace{-5.8}_{\text{C[4,8,NP]}} + \underbrace{-.36}_{\text{vp} \rightarrow \text{v np}}) \tag{3}$$

$$= \max(-8.1, -6.7) = -6.7 \tag{4}$$

Which is it? “dog through telescope” or “dog holding telescope”?

Span 7

1. $C[1,8,s] = \underbrace{-3.9}_{\text{C[1,2,NP]}} + \underbrace{-6.7}_{\text{C[3,8,VP]}} = -10.6$