



Constituency Parsing

Natural Language Processing: Jordan
Boyd-Graber

University of Maryland

EXERCISE

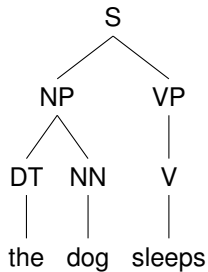
A pcfg

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

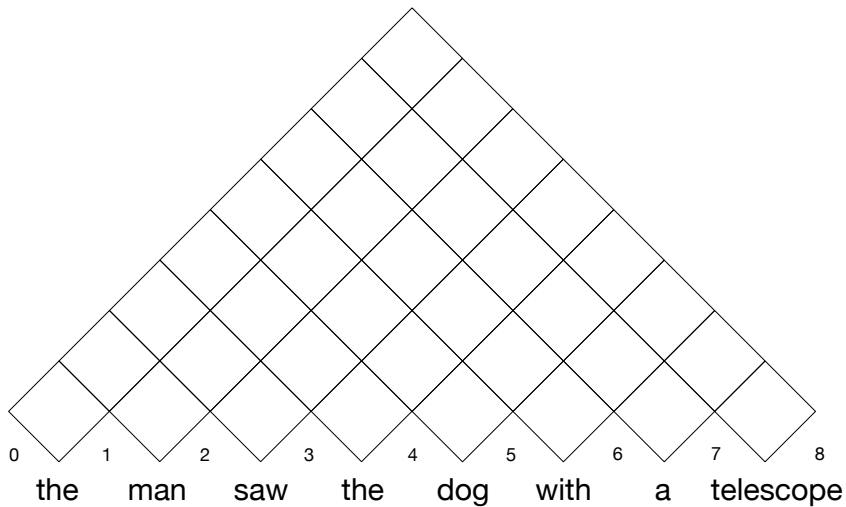
1 2 3 4 5 6 7 8
the man saw the dog with a telescope

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., $C[8, 8, \text{nn}]$).

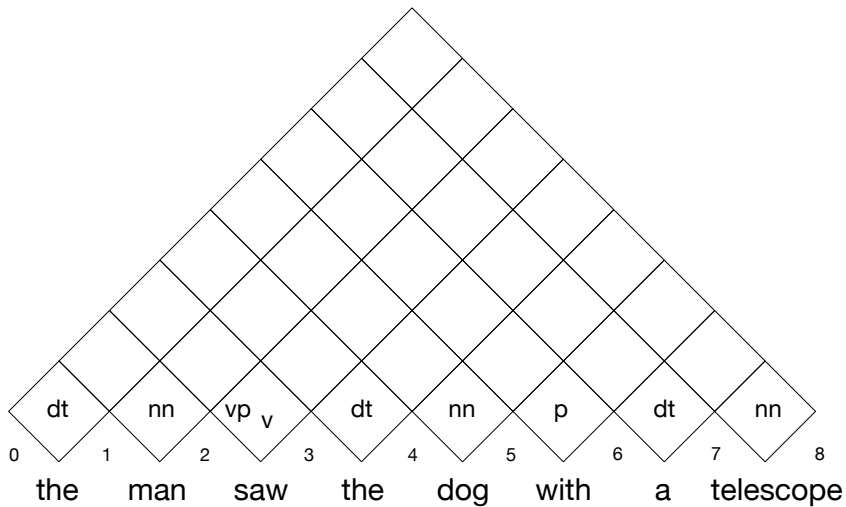
Blank Chart



Span 1

1. $C[7, 8, \text{nn}] = \ln(0.3) = -1.2$
2. $C[6, 7, \text{dt}] = \ln(1.0) = 0.0$
3. $C[5, 6, \text{p}] = \ln(0.6) = -0.51$
4. $C[4, 5, \text{nn}] = \ln(0.5) = -0.69$
5. $C[3, 4, \text{dt}] = \ln(1.0) = 0.0$
6. $C[2, 3, \text{v}] = \ln(0.6) = -.51$
7. $C[2, 3, \text{vp}] = \ln(0.6) + \ln(0.1) = -2.8$
8. $C[1, 2, \text{nn}] = \ln(0.1) = -2.3$
9. $C[0, 1, \text{dt}] = \ln(1.0) = 0.0$

Span 1



Span 2

$$1. C[0,2,np] = \underbrace{0.0}_{C[0,1,DT]} + \underbrace{-2.3}_{C[1,2,NN]} + \ln\left(\underbrace{0.2}_{np \rightarrow dt \ n}\right) = -2.3 + -1.6 = -3.9$$

Span 2

$$1. C[0,2,np] = \underbrace{0.0}_{C[0,1,DT]} + \underbrace{-2.3}_{C[1,2,NN]} + \ln(\underbrace{0.2}_{np \rightarrow dt \ n}) = -2.3 + -1.6 = -3.9$$

$$2. C[3,5,np] = \underbrace{0.0}_{C[3,4,DT]} + \underbrace{-0.69}_{C[4,5,NN]} + \ln(\underbrace{0.2}_{np \rightarrow dt \ n}) = -0.69 + -1.6 = -2.3$$

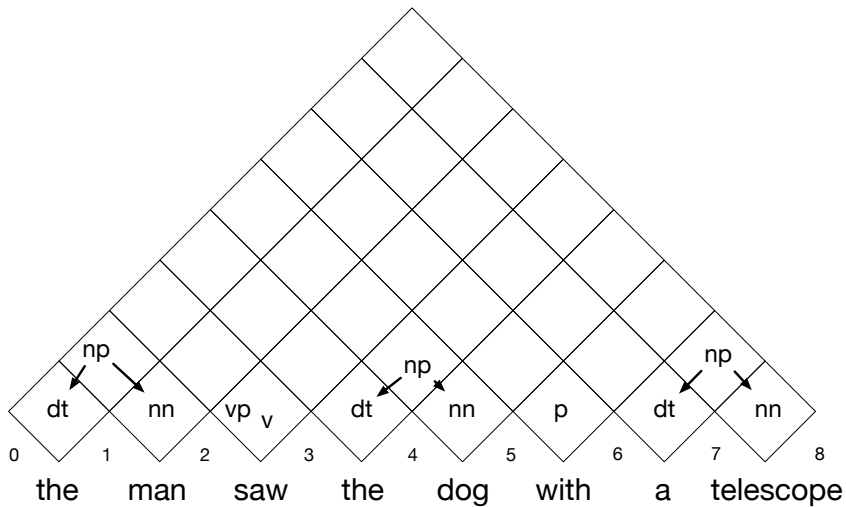
Span 2

$$1. C[0,2,np] = \underbrace{0.0}_{C[0,1,DT]} + \underbrace{-2.3}_{C[1,2,NN]} + \ln\left(\underbrace{0.2}_{np \rightarrow dt\ n}\right) = -2.3 + -1.6 = -3.9$$

$$2. C[3,5,np] = \underbrace{0.0}_{C[3,4,DT]} + \underbrace{-0.69}_{C[4,5,NN]} + \ln\left(\underbrace{0.2}_{np \rightarrow dt\ n}\right) = -0.69 + -1.6 = -2.3$$

$$3. C[6,8,np] = \underbrace{0.0}_{C[6,7,DT]} + \underbrace{-1.2}_{C[7,8,NN]} + \ln\left(\underbrace{0.2}_{np \rightarrow dt\ n}\right) = -1.2 + -1.6 = -2.8$$

Span 2



Span 3

$$1. C[0,3,s] = \underbrace{-3.9}_{C[0,2,NP]} + \underbrace{-2.8}_{C[2,3,VP]} + \ln\left(\underbrace{1.0}_{s \rightarrow np \text{ } vp}\right) = -6.7$$

Span 3

$$1. C[0, 3, s] = \underbrace{-3.9}_{C[0,2,NP]} + \underbrace{-2.8}_{C[2,3,VP]} + \ln\left(\underbrace{1.0}_{s \rightarrow np \text{ } vp}\right) = -6.7$$

$$2. C[2, 5, vp] = \underbrace{-0.5}_{C[2,3,V]} + \underbrace{-2.3}_{C[3,5,NP]} + \ln\left(\underbrace{0.7}_{vp \rightarrow v \text{ } np}\right) = -2.8 - 0.36 = -3.2$$

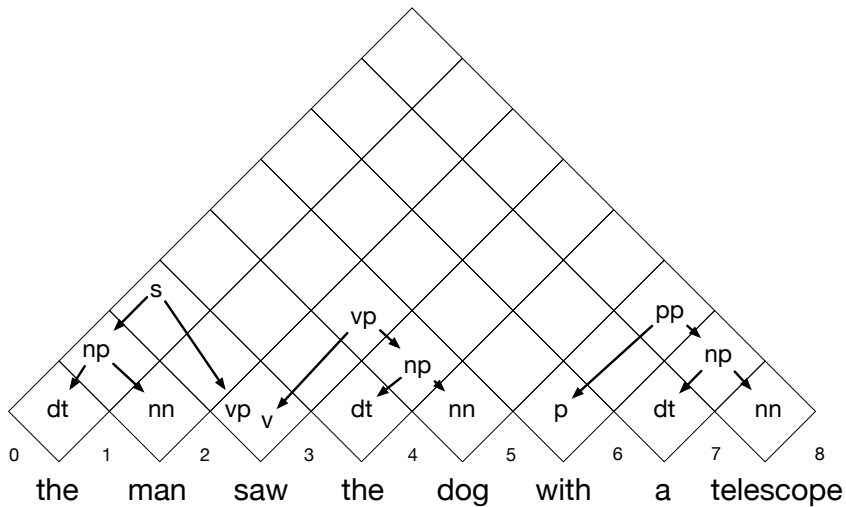
Span 3

$$1. C[0, 3, s] = \underbrace{-3.9}_{C[0,2,NP]} + \underbrace{-2.8}_{C[2,3,VP]} + \ln\left(\underbrace{1.0}_{s \rightarrow np \text{ } vp}\right) = -6.7$$

$$2. C[2, 5, vp] = \underbrace{-0.5}_{C[2,3,V]} + \underbrace{-2.3}_{C[3,5,NP]} + \ln\left(\underbrace{0.7}_{vp \rightarrow v \text{ } np}\right) = -2.8 - 0.36 = -3.2$$

$$3. C[5, 8, pp] = \underbrace{-0.51}_{C[5,6,P]} + \underbrace{-2.8}_{C[6,8,NP]} + \ln\left(\underbrace{1.0}_{pp \rightarrow p \text{ } np}\right) = -3.3 + -1.6 = -3.3$$

Span 3



Span 5

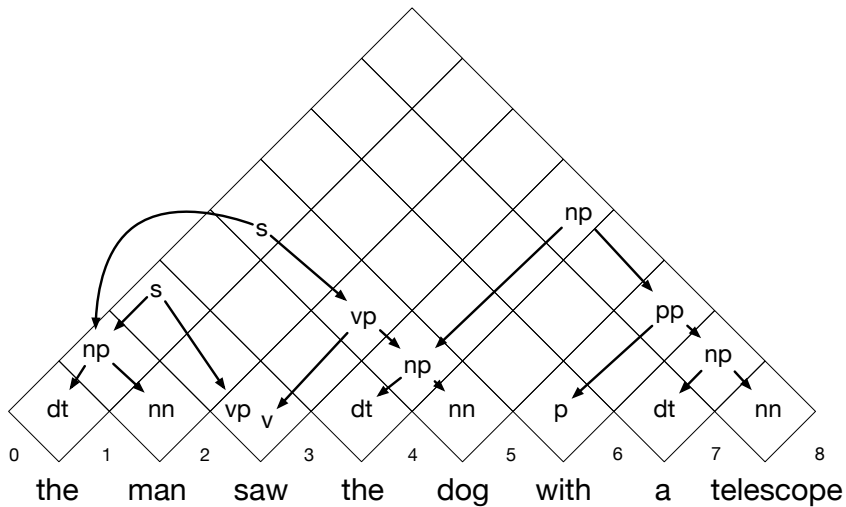
$$1. C[0,5,s] = \underbrace{-3.9}_{C[0,2,NP]} + \underbrace{-3.2}_{C[2,5,VP]} + \ln(\underbrace{1.0}_{s \rightarrow np \text{ } vp}) = -7.1$$

Span 5

$$1. C[0,5,s] = \underbrace{-3.9}_{C[0,2,NP]} + \underbrace{-3.2}_{C[2,5,VP]} + \ln\left(\underbrace{1.0}_{s \rightarrow np \text{ vp}}\right) = -7.1$$

$$2. C[3,8,np] = \underbrace{-2.3}_{C[3,5,NP]} + \underbrace{-3.3}_{C[5,8,PP]} + \ln\left(\underbrace{0.8}_{np \rightarrow np \text{ pp}}\right) = -5.6 + -0.2 = -5.8$$

Span 5



Span 6

$$C[2, 8, vp] = \max(\quad) \quad (1)$$

$$\underbrace{-3.2}_{C[2,5,VP]} + \underbrace{-3.3}_{C[5,8,PP]} + \underbrace{-1.6}_{vp \rightarrow vp\ pp}, \quad (2)$$

$$\underbrace{-0.5}_{C[2,3,V]} + \underbrace{-5.8}_{C[3,8,NP]} + \underbrace{-0.36}_{vp \rightarrow v\ np}) \quad (3)$$

$$= \max(-8.1, -6.7) = -6.7 \quad (4)$$

Span 6

$$C[2, 8, vp] = \max(\quad) \quad (1)$$

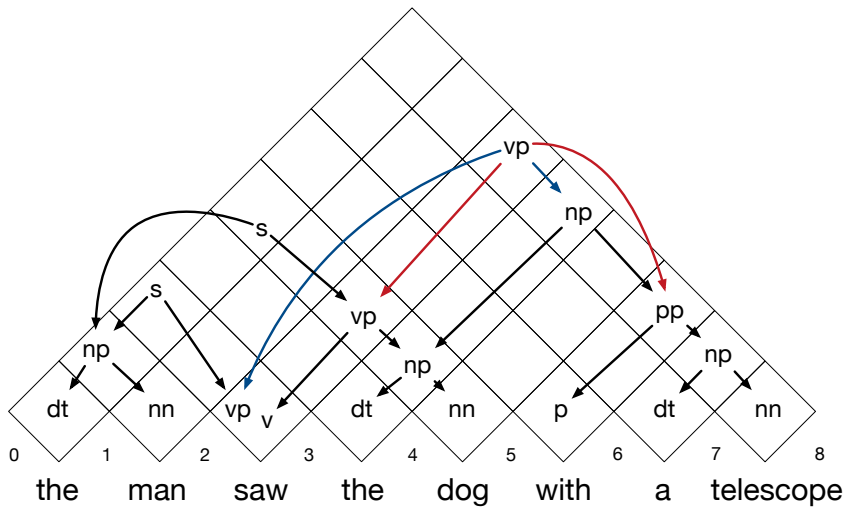
$$\underbrace{-3.2}_{C[2,5,VP]} + \underbrace{-3.3}_{C[5,8,PP]} + \underbrace{-1.6}_{vp \rightarrow vp\ pp}, \quad (2)$$

$$\underbrace{-0.5}_{C[2,3,V]} + \underbrace{-5.8}_{C[3,8,NP]} + \underbrace{-0.36}_{vp \rightarrow v\ np}) \quad (3)$$

$$= \max(-8.1, -6.7) = -6.7 \quad (4)$$

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

Span 6



Span 8

$$1. C[0,8,s] = \underbrace{-3.9}_{C[0,2,NP]} + \underbrace{-6.7}_{C[2,8,VP]} = -10.6$$

Span 8

