

CS-5340/6340, Written Assignment #2
DUE: Wednesday, Sept. 30, 2015 by 11:00pm

1. (24 pts) For each recursive transition network (RTN) below, write a grammar that accepts exactly the same language as the RTN.

(a) RTN #1:

Solution:

$PP \rightarrow prep PP1$
 $PP1 \rightarrow noun PP2$
 $PP1 \rightarrow PP4$
 $PP2 \rightarrow PP3$
 $PP3 \rightarrow PP$
 $PP4 \rightarrow noun$

(b) RTN #2:

Solution:

$NP \rightarrow art NP1$
 $NP \rightarrow adj NP2$
 $NP1 \rightarrow adj NP1$
 $NP1 \rightarrow NP3$
 $NP3 \rightarrow noun$
 $NP3 \rightarrow noun NP3$
 $NP2 \rightarrow adj NP2$
 $NP2 \rightarrow NP3$

(c) RTN #3:

Solution:

$VP \rightarrow VP1$
 $VP \rightarrow adv VP$
 $VP1 \rightarrow verb$
 $VP \rightarrow verb VP1$
 $VP1 \rightarrow inf VP2$
 $VP2 \rightarrow VP3$
 $VP3 \rightarrow verb$

2. (30 pts) Consider the grammar and lexicon below:

Grammar	Lexicon
$S \rightarrow NP VP$	<i>trust</i> : noun, verb
$NP \rightarrow \text{noun}$	<i>shrinks</i> : noun, verb
$NP \rightarrow \text{noun noun}$	
$VP \rightarrow \text{verb}$	
$VP \rightarrow \text{verb NP}$	

List all of the entries that would be put on the chart during **bottom-up chart parsing** for the sentence ‘**trust shrinks**’. Each chart entry should be a constituent or a rule, with a start and end position indicating which words have been matched by the constituent or rule.

To get you started, the list below contains chart entries for the part-of-speech tag constituents for the words ‘trust’ and ‘shrinks’ and for two rules that should be on the chart. Your job is to complete this list by adding the rest of the constituents and rules that would be put on the chart during parsing.

For the rules, please use an asterisk (*) to separate the components of the rule that have been matched from the ones that have not yet been matched. For example, the rule “ $NP \rightarrow \text{noun} * \text{noun}$ [1-2]” means that the first noun in this rule has been successfully matched with a constituent starting in position 1 and ending in position 2.

Complete the Chart Entries for Bottom-up Chart Parsing of ‘Trust Shrinks’

Constituent/Rule	Start-End
noun(“trust”)	[1-2]
verb(“trust”)	[1-2]
noun(“shrinks”)	[2-3]
verb(“shrinks”)	[2-3]
$NP \rightarrow \text{noun} *$	[1-2]
$NP \rightarrow \text{noun} * \text{noun}$	[1-2]
$S \rightarrow NP * VP$	[1-2]
$VP \rightarrow \text{verb} *$	[1-2]
$VP \rightarrow \text{verb} * NP$	[1-2]
$NP \rightarrow \text{noun} *$	[2-3]
$NP \rightarrow \text{noun} * \text{noun}$	[2-3]
$NP \rightarrow \text{noun noun} *$	[1-3]
$S \rightarrow NP * VP$	[1-3]
$S \rightarrow NP * VP$	[2-3]
$VP \rightarrow \text{verb} *$	[2-3]
$VP \rightarrow \text{verb} * NP$	[2-3]
$VP \rightarrow \text{verb NP} *$	[1-3]
$S \rightarrow NP VP *$	[1-3]

3. (16 pts) Consider the following tongue twister:

whether the weather is warm , whether the weather is hot , we have to
put up with the weather , whether we like it or not .

Using the tongue twister above as your text corpus, compute the following probabilities. Note that this text sample contains 28 words because each comma and period counts as a word. *Please leave your answers in fractional form with the frequency counts used for the computation! For example, we want to see answers of the form $14/28$, not $.50$*

- $P(\text{"or"}) = 1/28$
- $P(\text{"weather"}) = 3/28$
- $P(\text{"weather"} \mid \text{"the"}) = 3/3 = 1$
- $P(\text{"whether"} \mid \text{"we"}) = 0/2 = 0$
- $P(\text{"warm"} \mid \text{"is"}) = 1/1 = 1$
- $P(\text{"hot"} \mid \text{"weather"}, \text{"is"}) = 1/2$
- $P(\text{"is"} \mid \text{"the"}, \text{"weather"}) = 2/3$
- $P(\text{"up"} \mid \text{"to"}, \text{"put"}) = 1/1 = 1$

4. (18 pts) Consider the sentence:

John Smith planned to fish for silver trout and char but he forgot to bring the fishing gear

Suppose your part-of-speech (POS) tagger assigns these POS tags to the sentence:

John/NOUN Smith/NOUN planned/VERB to/PREP fish/NOUN for/PREP silver/NOUN trout/NOUN and/CONJ char/VERB but/CONJ he/PRO forgot/VERB to/INF bring/VERB the/ART fishing/VERB gear/NOUN

Assume that the **correct** POS tags for the sentence are:

John/NOUN Smith/NOUN planned/VERB to/INF fish/VERB for/PREP silver/ADJ trout/NOUN and/CONJ char/NOUN but/CONJ he/PRO forgot/VERB to/INF bring/VERB the/ART fishing/GER gear/NOUN

Based on the information above, answer the questions below. Please leave your answers in fractional form!

- (a) What is the overall accuracy of your POS tagger? Answer: 13/18
- (b) What is the recall of your POS tagger for verbs? Answer : 3/4
- (c) What is the precision of your POS tagger for verbs? Answer: 3/5
- (d) What is the recall of your POS tagger for nouns? Answer: 4/5
- (e) What is the precision of your POS tagger for nouns? Answer: 4/6
- (f) What is the recall of your POS tagger for prepositions (PREP tag)? Answer: $1/1 = 1$
- (g) What is the precision of your POS tagger for prepositions (PREP tag)? Answer: 1/2
- (h) Using the **correct** POS tags, what is the lexical generation probability $P(\text{planned} \mid \text{VERB})$? Answer: 1/4
- (i) Using the **correct** POS tags, what is $P(\text{VERB} \mid \text{planned})$, which means the probability that the word “planned” should have the tag VERB? Answer: $1/1 = 1$

5. (12 pts) Consider the probability that the sentence “*A witty saying proves nothing*” (a quote from Voltaire) should be assigned the part-of-speech (POS) tag sequence “*ART ADJ NOUN VERB NOUN*”.

$$P(\text{ART ADJ NOUN VERB NOUN} \mid \text{A witty saying proves nothing})$$

If you perform statistical part-of-speech tagging with N-gram language models to compute this probability, show the equation that would be used for each type of N-gram language model below. You must instantiate the equation with the specific words and part-of-speech tags shown above, but no numbers are needed.

If necessary, use the symbol ϕ_0 to denote the beginning of a sentence (i.e., the position immediately to the left of the first word) and the symbol ϕ_{-1} to denote two positions to the left of the first word.

- (a) Show the equation using a unigram language model.

Answer: $P(A|\text{ART}).P(\text{ART}).P(\text{witty}|\text{ADJ}).P(\text{ADJ}).P(\text{saying}|\text{NOUN}).P(\text{NOUN}).P(\text{proves}|\text{VERB}).P(\text{VERB}).P(\text{nothing}|\text{NOUN}).P(\text{NOUN})$

- (b) Show the equation using a bigram language model.

Answer: $P(\text{ART} \mid \phi_0).P(A|\text{ART}).P(\text{ADJ}|\text{ART}).P(\text{witty}|\text{ADJ}).P(\text{NOUN}|\text{ADJ}).P(\text{saying}|\text{NOUN}).P(\text{VERB}|\text{NOUN}).P(\text{proves}|\text{VERB}).P(\text{NOUN}|\text{VERB}).P(\text{nothing}|\text{NOUN})$

- (c) Show the equation using a trigram language model. Each trigram should be written as $P(Z \mid X Y)$, where X precedes Y in the input.

Answer: $P(\text{ART} \mid \phi_{-1} \phi_0).P(A|\text{ART}).P(\text{ADJ} \mid \phi_0 \text{ART}).P(\text{witty}|\text{ADJ}).P(\text{NOUN}|\text{ART ADJ}).P(\text{saying}|\text{NOUN}).P(\text{VERB}|\text{ADJ NOUN}).P(\text{proves}|\text{VERB}).P(\text{NOUN}|\text{NOUN VERB}).P(\text{nothing}|\text{NOUN})$

Question #6 is for CS-6340 students ONLY!

6. (18 pts) Consider the grammar and lexicon below:

Grammar	Lexicon
$S \rightarrow NP VP$	<i>trust</i> : noun, verb
$NP \rightarrow \text{noun}$	<i>shrinks</i> : noun, verb
$NP \rightarrow \text{noun noun}$	
$VP \rightarrow \text{verb}$	
$VP \rightarrow \text{verb NP}$	

List all of the entries that would be put on the chart during **top-down chart parsing** for the sentence ‘**trust shrinks**’. Each chart entry should be a constituent or a rule, with a start and end position indicating which words have been matched by the constituent or rule.

To get you started, the list below contains chart entries for the part-of-speech tag constituents for the words ‘trust’ and ‘shrinks’ and for three rules that should be on the chart. Your job is to complete this list by adding the rest of the constituents and rules that would be put on the chart during parsing.

For the rules, please use an asterisk (*) to separate the components of the rule that have been matched from the ones that have not yet been matched. For example, the rule “ $NP \rightarrow * \text{noun noun} [1-1]$ ” means that no nouns in this rule have been matched yet but the rule can begin matching constituents starting in position 1.

Complete the Chart Entries for Top-down Chart Parsing of ‘Trust Shrinks’

Constituent/Rule	Start-End
noun("trust")	[1-2]
verb("trust")	[1-2]
noun("shrinks")	[2-3]
verb("shrinks")	[2-3]
S \rightarrow * NP VP	[1-1]
NP \rightarrow * noun	[1-1]
NP \rightarrow * noun noun	[1-1]
VP \rightarrow * verb	[1-1]
VP \rightarrow * verb NP	[1-1]
NP \rightarrow noun *	[1-2]
NP \rightarrow noun * noun	[1-2]
S \rightarrow NP * VP	[1-2]
VP \rightarrow verb *	[1-2]
VP \rightarrow verb * NP	[1-2]
NP \rightarrow noun noun *	[1-3]
VP \rightarrow verb NP *	[1-3]
NP \rightarrow noun *	[2-3]
NP \rightarrow noun * noun	[2-3]
S \rightarrow NP * VP	[2-3]
S \rightarrow NP VP *	[1-3]
VP \rightarrow verb *	[2-3]
VP \rightarrow verb * NP	[2-3]