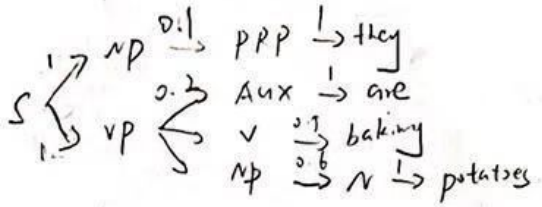
Homework 2 Xiaonei Zhao

Analytical Component

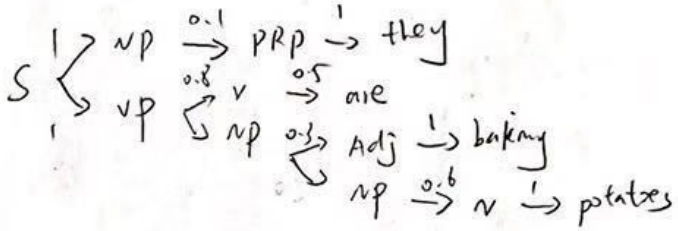
Problem 1

a) The first sequence is



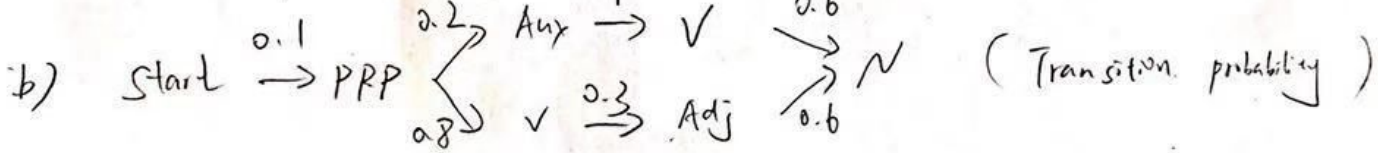
The joint probability for this sequence is $1\times1\times0.1\times0.2\times1\times0.5\times0.6\times1 = 0.006$

The second sequence is



the joint probability for this sequence is $1\times0.1\times1\times0.8\times0.5\times0.3\times1\times0.6\times1 = 0.0072$.

b)



(Transition probability)

they are baking potatoes

PRP $\xrightarrow{1}$ they V $\xrightarrow{0.5}$ are V $\xrightarrow{0.5}$ baking Aux $\xrightarrow{1}$ are.

N $\xrightarrow{1}$ potatoes Adj $\xrightarrow{1}$ baking (Emission probability).

c) It is possible to translate any PCFG into an HMM that produces the identical joint probability P(tags, words) as the PCFG.

Since PCFG is to deal with CFG language and HMM usually deals with regular language, pCFG is much more stronger.

Problem 2.

a) S → NP VP
NP → Adj NP
NP → PRP
NP → N
VP → V NP
VP → Aux V NP
PRP → they
N → potatoes
Adj → baking
V → baking
V → are
Aux → are

they are baking potatoes
0 1 2 3 4

Chart [0]

S_0	S → • NP VP	[0,0]	init
S_1	NP → • Adj NP	[0,0]	predict S_0
S_2	NP → • PRP	[0,0]	predict S_0
S_3	NP → • N	[0,0]	predict S_0
S_4	Adj → • baking	[0,0]	predict S_1
S_5	PRP → • they	[0,0]	predict S_2
S_6	N → • potatoes	[0,0]	predict S_3

Chart [1]

✓ S_7	PRP → they •	[0,1]	Scan S_5
✓ S_8	NP → PRP •	[0,1]	complete S_2 with S_7
S_9	S → NP • VP	[0,1]	complete S_0 with S_7
S_{10}	VP → • V NP	[1,1]	predict S_9
S_{11}	VP → • Aux V NP	[1,1]	predict S_9
S_{12}	V → • baking	[1,1]	predict S_{10}
S_{13}	V → • are	[1,1]	predict S_{10}
S_{14}	Aux → • are	[1,1]	predict S_{11}

Chart [2]

S15 V → are • [1,2] scan S13

S16 Aux → are • [1.2] scan S14

S17 VP → V • NP [1,2] complete S10 with S15

S18 VP → Aux • V NP [1.2] complete S11 with S16.

S19 NP → • Adj NP [2,2] predict S17

S20 NP → • PRP [2,2] predict S17

S21 NP → • N [2,2] predict S17

S22 V → • baking [2,2] predict S18

S23 V → • are [2.2] predict S18

S24 Adj → • baking [2,2] predict S19

S25 PRP → • they [2.2] predict S20

S26 N → • potatoes [2,2] predict S21

Chart [3].

S27 V → baking • [2,3] scan S22

S28 Adj → baking • [2,3] scan S24.

S29 VP → Aux V • NP [1.3] complete S18 with S27

S30 NP → Adj • NP [2,3] complete S19 with S28

S31 NP → • Adj NP [3,3] predict S29 and S30

S32 NP → • PRP [3.3] predict S29 and S30

S33 NP → • N [3.3] predict S29 and S30.

S34 Adj → • baking [3.3] predict S31

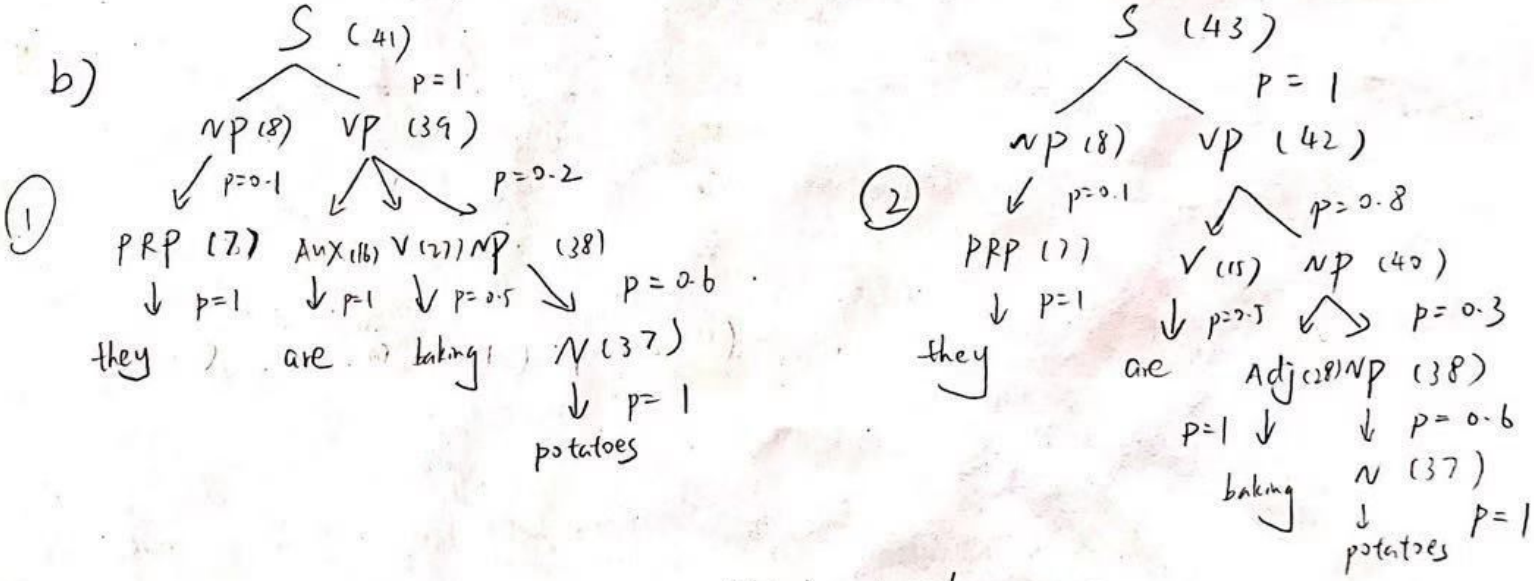
S35 PRP → • they [3.3] predict S32

S36 N → • potatoes [3.3] predict S33.

Chart [4]:

- S37 N → potatoes. [3,4] scan S36
- S38 NP → N. [3,4] complete S33 with S37
- S39 VP → Aux V NP. [1,4] complete S29 with S38
- S40 NP → Adj NP. [2,4] complete S30 with S38
- S41 S → NP VP. [0,4] complete S9 with S39
- S42 VP → V NP. [1,4] complete S17 with S39
- S43 S → NP VP. [0,4] complete S9 with S42

b)



$P(①) = 1 \times 0.1 \times 0.2 \times 1 \times 1 \times 0.5 \times 0.6 \times 1 = 0.006$

$P(②) = 1 \times 0.1 \times 0.8 \times 1 \times 0.5 \times 0.3 \times 1 \times 0.6 \times 1 = 0.0072$

Problem 3

a). The new grammer is :

$S \to NP\ VP$
$NP \to Adj\ NP$
$NP \to they$
$NP \to potatoes$
$VP \to V\ NP$
$VP \to Aux\_V\ NP$
$Aux\_V \to Aux\ V$
$Adj \to baking$
$V \to baking$
$V \to are$
$Aux \to are.$

1. Rules of the form $A \to B$:

We find the production of B, say if $B \to C$, then replace $A \to B$ with $A \to C$ and $B \to C$ with $A \to C$

2. Rules of the form $A \to B\ C\ D\ E$:

If $B\ C\ D\ E$ are non-terminals, we create new non-terminal like $X \to BC$, $Y \to DE$

Then we can replace $A \to BCDE$ with $A \to XY$

b)

	0	1 (they)	2 (are)	3 (baking)	4 (potatoes)
0		NP	VP	VP	S, S, S
1			V, Aux	Aux_V	VP
2				Adj, V	VP, NP
3					NP
4					

$VP[0,2] \to NP[0,1],\ V[1,2]$

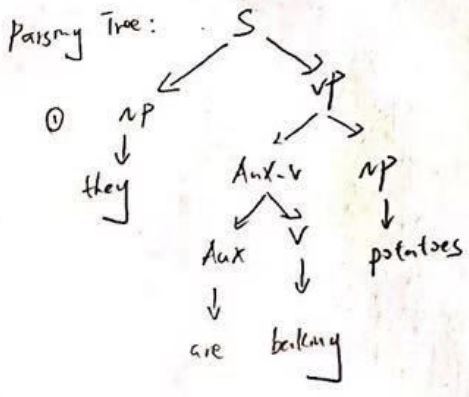
$Aux\_V[1,3] \to Aux[1,2],\ V[2,3].$

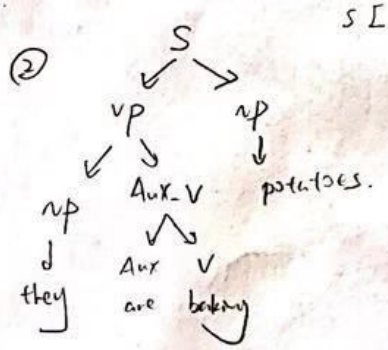
$VP[2,4] \to V[2,3],\ NP[3,4]$
$NP[2,4] \to Adj[2,3],\ NP[3,4].$
$VP[0,3] \to NP[0,1],\ Aux\_V[1,3].$

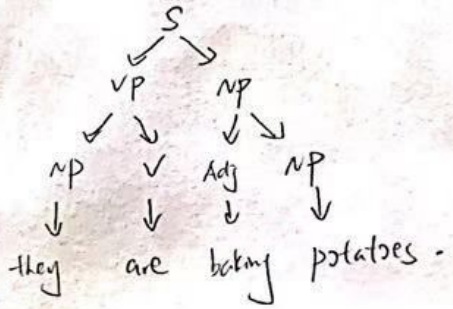
$VP[1,4] \to Aux\_V[1,3],\ NP[3,4].$

$S[0,4] = NP[0,1],\ VP[1,4].$
$S[0,4] = VP[0,3],\ NP[3,4].$
$S[0,4] = VP[0,2],\ NP[2,4].$

Parsing Tree:







Problem 4.

① initial state

↓ shift (next transition) A:

σ: root β: he sent her a funny meme today

② A:

left-Arc σ: $\frac{he}{root}$ β: sent her a funny meme today

③ A: he ←nsubj— sent

shift σ: root β: sent her a funny meme today

④ A: he ←nsubj— sent

right σ: $\frac{sent}{root}$ β: her a funny meme today

⑤ A: he ←nsubj— sent —iobj→ her

shift σ: $\frac{}{root}$ β: sent a funny meme today

⑥ A: he ←nsubj— sent —iobj→ her

shift σ: $\frac{sent}{root}$ β: a funny meme today

⑦ A: he ←nsubj— sent —iobj→ her

shift σ: $\frac{a}{\frac{sent}{root}}$ β: funny meme today

⑧ A: he ←nsubj— sent —iobj→ her

left-Arc σ: $\frac{funny}{\frac{a}{\frac{sent}{root}}}$ β: meme today

⑨ A: he ←nsubj— sent —iobj→ her, funny ←amod— meme

left-Arc σ: $\frac{a}{\frac{sent}{root}}$ β: meme today

⑩ A: he ←nsubj— sent —iobj→ her, a ←det— , funny ←amod— meme

right-Arc σ: $\frac{sent}{root}$ β: meme today

⑪ A: he ←nsubj— sent —iobj→ her, a ←det— , funny ←amod— meme, sent —dobj→ meme

shift σ: root β: sent today

⑫ A: he ←nsubj— sent —iobj→ her, a ←det— , funny ←amod— meme, sent —dobj→ meme

right-Arc σ: $\frac{sent}{root}$ β: today

⑬ he ←nsubj— sent —iobj→ her, a ←det— , funny ←amod— meme, sent —dobj→ meme, sent —advmod→ today.

right-Arc σ: root β: sent

⑭ root —pred→ he ←nsubj— sent —iobj→ her, a ←det— , funny ←amod— meme, sent —dobj→ meme, sent —advmod→ today.

shift σ: [ ] β: root.

Terminal:

root —pred→ he ←nsubj— sent —iobj→ her, a ←det— , funny ←amod— meme, sent —dobj→ meme, sent —advmod→ today.

σ: root β: [ ]