CS-5340/6340, Written Assignment #2
dfhsdofi-u1059566

1. (15 pts)

NOUN	FREQ	UNSMOOTHED PROB	SMOOTHED FREQ	SMOOTHED PROB
maple	600	$\frac{600}{1200} = 0.50$	$\frac{601}{1205} \times 1200 = 598.50$	$\frac{601}{1205} = 0.4988$
oak	400	$\frac{400}{1200} = 0.33$	$\frac{401}{1205} \times 1200 = 399.33$	$\frac{401}{1205} = 0.3328$
pine	180	$\frac{180}{1200} = 0.15$	$\frac{401}{1205} \times 1200 = 180.24$	$\frac{181}{1205} = 0.1502$
spruce	20	$\frac{20}{1200} = 0.01$	$\frac{401}{1205} \times 1200 = 20.91$	$\frac{21}{1205} = 0.0174$
aspen	0	$\frac{0}{1200} = 0.00$	$\frac{401}{1205} \times 1200 = 0.9958$	$\frac{1}{1205} = 0.0008$

2. (a) **Grammar A and Grammar B:**
   Different:
   Grammar A can't accept a POS sequence starting with a *noun*. For example, a sequence *"noun noun"* can't be parsed by *grammar A* as it requires an *article* to begin.

   (b) **Grammar A and Grammar C:**
   Same:
   Both grammars can accept same inputs.

   (c) **Grammar A and RTN-2:**
   Different:
   Grammer A can't accept any sequence starting with an *adjective*. For example, a sequence *"adj adj noun"* can't be parsed by *Grammer A*.

   (d) **Grammar A and RTN-3:**
   Same:
   Both can accept same inputs.

   (e) **Grammar B and RTN-2:**
   Different:
   Grammer B can't accept any sequence starting with an *adjective*. For example, a sequence *"adj adj noun"* can't be parsed by *Grammer B*.

   (f) **Grammar C and RTN-1:**
   Same:
   Both can accept same inputs.

   (g) **Grammar C and RTN-3:**
   Same:
   Both can accept same inputs.

   (h) **RTN-1 and RTN-3:**
   Different:
   RTN-3 can only accept any sequence ending with a *noun* while *RTN-1* can also end on an *adjective*. For example, a sequence *" art adj adj"* can't be parsed by *RTN-3* as it requires a *noun* to end.

3. (24 pts) **Compute the probabilities listed below. Please show each probability as a fraction (numerator/denominator)!**

(a) $P(the) = \frac{5}{34} = 0.147$

(b) $P(VERB) = \frac{6}{34} = 0.176$

(c) $P(young \mid girl) = \frac{0}{3} = 0$

(d) $P(girl \mid young) = \frac{2}{2} = 1$

(e) $P(and \mid woman) = \frac{1}{3} = 0.33$

(f) $P(thanked \mid young\ girl) = \frac{0}{2} = 0$

(g) $P(five \mid gave\ her) = \frac{1}{2} = 0.5$

(h) $P(the \mid ART) = \frac{5}{8} = 0.625$

(i) $P(cross \mid NOUN) = \frac{0}{9} = 0$

(j) $P(thanked \mid VERB) = \frac{2}{6} = 0.33$

(k) $P(NUM \mid PRO) = \frac{1}{2} = 0.5$

(l) $P(ART \mid VERB) = \frac{4}{6} = 0.66$

4. (15 pts total) **Using the Viterbi algorithm, compute the probability for each of the following nodes in the network.**

   (a) P(light=VERB) = $P(VERB \mid \phi) \times P(light \mid VERB) = 0.25 \times 0.50 = 0.125$

   (b) P(light=NOUN) = $P(NOUN \mid \phi) \times P(light \mid NOUN) = 0.7 \times 0.60 = 0.42$

   (c) P(light=ADJ) = $P(ADJ \mid \phi) \times P(light \mid ADJ) = 0.2 \times 0.15 = 0.03$

   (d) P(shows=VERB) = $P(shows \mid VERB) \times \max\{P(VERB \mid NOUN) \times P(light \mid NOUN), P(VERB \mid VERB) \times P(light \mid VERB), P(VERB \mid ADJ) \times P(light \mid ADJ) = 0.30 \times \max\{0.50 \times 0.42, 0.40 \times 0.125, 0.10 \times 0.3\} = 0.063$

   (e) P(shows=NOUN) = $P(shows \mid NOUN) \times \max\{P(NOUN \mid NOUN) \times P(light \mid NOUN), P(NOUN \mid VERB) \times P(light \mid VERB), P(NOUN \mid ADJ) \times P(light \mid ADJ) = 0.40 \times \max\{0.80 \times 0.42, 0.30 \times 0.125, 0.60 \times 0.3\} = 0.1344$

   (f) P(shows=ADJ) = $P(shows \mid ADJ) \times \max\{P(ADJ \mid NOUN) \times P(light \mid NOUN), P(ADJ \mid VERB) \times P(light \mid VERB), P(ADJ \mid ADJ) \times P(light \mid ADJ) = 0.10 \times \max\{0.20 \times 0.42, 0.70 \times 0.125, 0.90 \times 0.003\} = 0.00875$

5. (15 pts) **For this question, use the same Viterbi network and probability tables shown in Question #4.**

(a) $P(light/VERB \mid light) = \dfrac{P(light/VERB)}{P(light)} = \dfrac{0.125}{0.575}$

(b) $P(light/NOUN \mid light) = \dfrac{P(light/NOUN)}{P(light)} = \dfrac{0.42}{0.575}$

(c) $P(light/ADJ \mid light) = \dfrac{P(light/ADJ)}{P(light)} = \dfrac{0.03}{0.575}$

(d) $P(shows/VERB \mid lightshows) = \dfrac{P(shows/VERB)}{P(lightsource)} = \dfrac{0.063}{0.2058}$

(e) $P(shows/NOUN \mid lightshows) = \dfrac{P(shows/NOUN)}{P(lightsource)} = \dfrac{0.1344}{0.2058}$

(f) $P(shows/ADJ \mid lightshows) = \dfrac{P(shows/ADJ)}{P(lightsource)} = \dfrac{0.00875}{0.2058}$