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CS 585 Spring 2024 Written Assignment #02

Due: **Sunday, February 11, 2024, 11:59 PM CST**

Points: **30**

Objectives:

1. (10 points) Demonstrate your understanding of Minimum Edit Distance algorithm.
2. (10 points) Demonstrate your understanding of the N-gram language modeling.
3. (10 points) Demonstrate your understanding of an HMM POS tagger.

Problem 1 [10 pts]

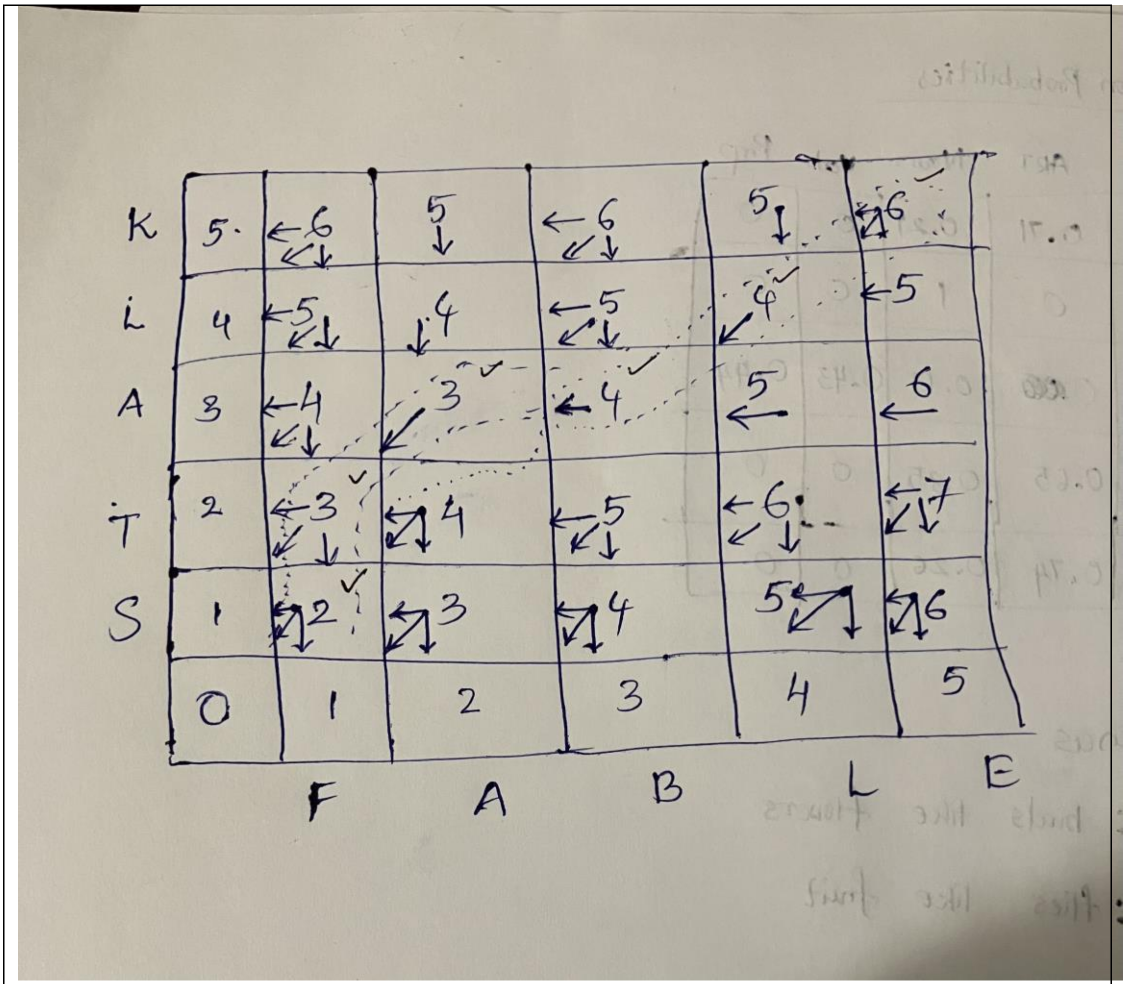
What is the **Minimum Edit Distance** between words STALK and FABLE (assume that insertion / deletion cost is 1, substitution cost is 2)? Populate the table below to find the MED. Include back pointers.

K						
L						
A						
T						
S						
#						
	#	**F**	**A**	**B**	**L**	**E**

Solution:

K	**5**	**6**	**5**	**6**	**5**	**6**
L	**4**	**5**	**4**	**5**	**4**	**5**
A	**3**	**4**	**3**	**4**	**5**	**6**
T	**2**	**3**	**4**	**5**	**6**	**7**
S	**1**	**2**	**3**	**4**	**5**	**6**
#	**0**	**1**	**2**	**3**	**4**	**5**
	#	**F**	**A**	**B**	**L**	**E**

Minimum Edit Distance:



K	5	←6 ↙↓	5 ↓	←6 ↙↓	5 ↓	←↙↓6
L	4	←5 ↙↓	↓4	←5 ↙↓	↙4	←5
A	3	←4 ↙↓	↙3	←4	5 ←	6 ←
T	2	←3 ↙↓	←↙↓4	←5 ↙↓	←6 ↙↓	←↙↓7
S	1	←↙↓2	←↙↓3	←↙↓4	5←↙↓	←↙↓6
	0	1	2	3	4	5
		F	A	B	L	E

Minimum Edit Distance = 6

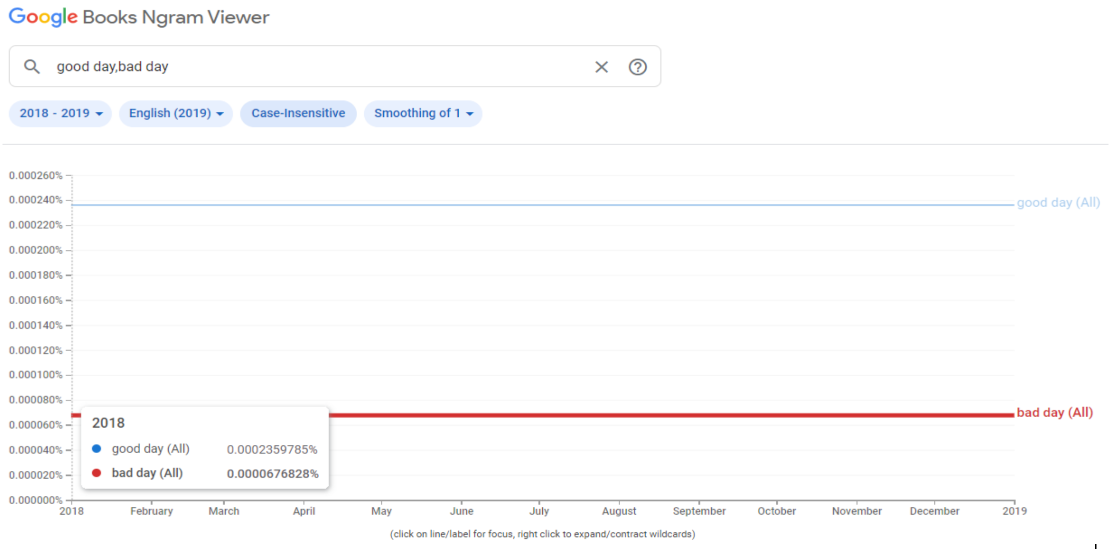
Problem 2 [10 pts]

Your task is to calculate probabilities of selected sentences in English using a language model (based on Google Books N-gram corpus). Use the Google N-Gram Viewer website (`https://books.google.com/ngrams`) to collect all necessary data (NOTE: Google provides N-gram PERCENTAGES – those are NOT COUNTS! and not exactly probabilities!) and calculate sentence probability.

NOTES:

- assume that probability of a any bigram starting or ending a sentence is 0.25.

- use the settings shown below (2018 probabilities, English (2019), case insensitive, Smoothing of 1)



Google Books Ngram Viewer

good day,bad day

2018 - 2019 ▾ English (2019) ▾ Case-Insensitive Smoothing of 1 ▾

2018

● good day (All) 0.0002359785%

● bad day (All) 0.0000676828%

(click on line/label for focus, right click to expand/contract wildcards)

A) **[5 pts]** Probability of a sentence:

Today is a good day

Relevant bigram probabilities [1 pt]:
(<s>, today) – 0.25 (Today, is) – 0.00039373768/100 = 0.399376*10^-5 (is, a) – 0.0562696642/100 = 0.005626 = 0.562696642*10^-5 (a, good) – 0.013680092/100 = 13.6860092*10^-5 (Good , day) – 0.0002368249/100 = 0.2368249*10^-5 (day, </s>) – 0.25
Probability of a sentence formula [2 pt]:

P(<s>, Today) * P(Today, is) * P(is, a) * P(a, good) * P(Good, day) * P(day, </s)

Probability of a sentence (calculations and value) [2 pt]:

(250 * 0.3993768 * 56.2696642 * 13.6860092 * 0.2368249 * 250) *10^-5 = **4.552*10^-5**

B) **[5 pts]** Probability of a sentence:

Today is a bad day

Relevant bigram probabilities [1 pt]:

(<s>, Today) = 0.25
(today, is) = 0.3993768*10^-5
(is, a) = 56.2696642*10^-5
(a, bad) = 1.963926 *10^-5
(bad, day) = 0.0680989 *10^-5
(day, </s>) = 0.25

Probability of a sentence formula [2 pt]:

P(<s>, Today) * P(Today, is) * P(is, a) * P(a, bad) * P(bad, day) * P(day, </s)

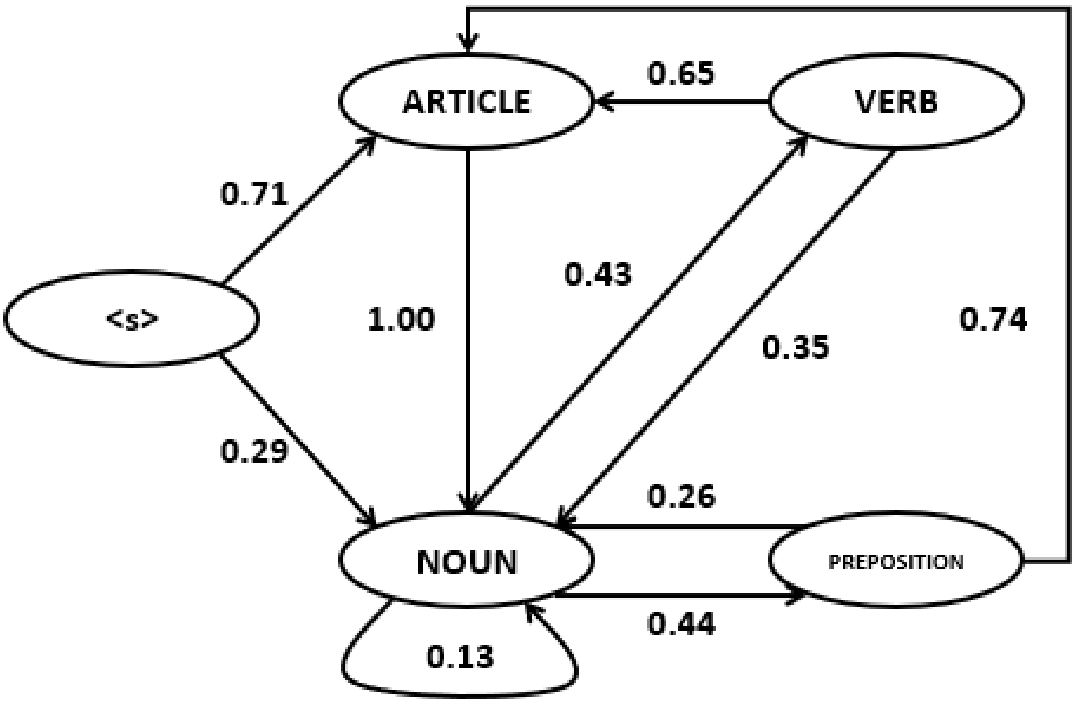
Probability of a sentence (calculations and value) [2 pt]:

(250 * 0.3993768 * 56.2696642*1.963926*0.0680989 *250) *10^-5

= **0.188*10^-5**

Problem 3 [10 pts]

Given the following Hidden Markov model (transition probabilities shown; emission probabilities to be determined by you using corpus C data) based on corpus C:



And the following table of selected word counts from some corpus C:

Word/Tag	N	V	ART	P	TOTAL
flies	21	23	0	0	44
fruit	49	5	1	0	55
like	10	30	0	21	61
a	1	0	201	0	202
the	1	0	300	2	303
flower	53	15	0	0	68
flowers	42	16	0	0	58
birds	64	1	0	0	65
others	592	210	56	284	1142
TOTAL	833	300	558	307	1998

Using the approach presented during the lecture, decide which sentence, S1:

birds like flower

or S2:

flies like fruit

is **more likely to be labeled with a sequence of tags N, V, N**. Show all your work.

Answer:
Second word is most likely to be labelled with sequence of tags because of the probability of 2nd sentence is greater than probability of first sentence.

Transition Probabilities.

	<S>	ART	Noun	Verb	Prep.
<S>	0	0.71	0.29	0	0
<ART>	0	0	1	0	0
<Noun	0	0	0.13	0.43	0.44
Verb	0	0.65	0.35	0	0
Prep	0	0.74	0.26	0	0

Given sentences

S1 : birds like flowers

S2 : flies like fruit

required: $P(\text{birds}, \text{like}, \text{flower} \mid N, V, N)$

we know $P(w_1, w_2, \dots) = \prod_{i=1}^{T} P(w_i \mid C_i) * P(C_i \mid C_{i-1})$

using ①, calculating probability $P(S_1)$

$$P\left(\frac{\text{birds}}{\text{Noun}}\right) P\left(\frac{\text{like}}{V}\right) P\left(\frac{\text{flower}}{N}\right) * P\left(\frac{N}{<S>}\right) P\left(\frac{V}{N}\right) P\left(\frac{N}{V}\right)$$

$$= \left(\frac{64}{833} \times 0.1 \times \frac{53}{833}\right) * \left(0.29 \times 0.43 \times 0.35\right)$$

$$\approx (0.0768 \times 0.1 \times 0.0636) * (0.29 \times 0.43 \times 0.35)$$

$$\approx 4.8 \times 10^{-4} * 0.044$$

Using ① Calculating for S2-

$$= \left(P\left(\frac{\text{flies}}{N}\right) \times P\left(\frac{\text{like}}{V}\right) \times P\left(\frac{\text{fruit}}{N}\right) * P\left(\frac{N}{<S>}\right) P\left(\frac{V}{N}\right) P\left(\frac{N}{V}\right)\right)$$

$$= \left(0.025 \times 0.1 \times \frac{49}{833}\right) * \left(0.29 \times 0.43 \times 0.35\right)$$

$$= \left(0.025 \times 0.1 \times 0.0588\right)\left(0.29 \times 0.43 \times 0.35\right)$$

$$= 1.47 \times 10^{-4} \times 0.044$$

Clearly $P(S1) > P(S2)$. So there are S1 is the suitable sentence