Natural Language Processing

Assignment 4

Type of Question: MCQ

Number of Questions: 7 Total Marks: $(4\times1)+(3\times2)=10$

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1.

Baum-Welch algorithm is an example of - **[Marks 1]**

A) Forward-backward algorithm
B) Not a case of the Expectation-maximisation algorithm
C) Both A and B
D) None

Answer: A

Solution: Theory.

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2. **Marks 2**

Once a day (e.g. at noon), the weather is observed as one of state 1: rainy state 2: cloudy state 3: sunny The state transition probabilities are :

0.4	0.3	0.3
0.2	0.6	0.2
0.1	0.1	0.8

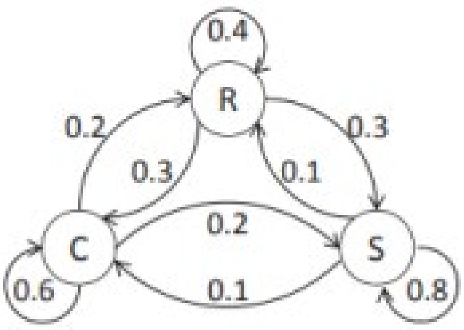
Given that the weather on day 1 (t = 1) is sunny (state 3), what is the probability that the weather for the next 7 days will be “sun-sun-rain-rain-sun-cloudy-sun”?

A) $1.54 * 10^{-4}$
B) $8.9 * 10^{-2}$
C) $7.1 * 10^{-7}$
D) $2.5 * 10^{-10}$

Answer: A

Solution:

O = {S3, S3, S3, S1, S1, S3, S2, S3}
P(O | Model)
= P(S3, S3, S3, S1, S1, S3, S2, S3 | Model)
= P(S3) P(S3|S3) P(S3|S3) P(S1|S3) P(S1|S1) P(S3|S1) P(S2| S3)
P(S3|S2) = Q3 · a33 · a33 · a31 · a11 · a13 · a32 · a23
= (1)(0.8)(0.8)(0.1)(0.4)(0.3)(0.1)(0.2)
= 1.536 × 10-4



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3.

In the question 2, the expected number of consecutive days of sunny weather is:

A) 2
B) 3
C) 4
D) 5

[Marks 1]

Answer: D

Solution:
Exp(i) = 1/(1-p_{ii}) So for rainy, the expected no of days = 1/(1-0.8) = 5

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4. **[Marks 2]**

You are building a model distribution for an infinite stream of word tokens. You know that the source of this stream has a vocabulary of size 1200. Out of these 1200 words you know of 200 words to be stop words each of which has a probability of 0.001. With only this knowledge what is the maximum possible entropy of the modelled distribution. (Use log base 10 for entropy calculation)

A) 2.079
B) 4.5084
C) 2.984
D) 3.0775

Answer: D

Solution: There are 200 stopwords with each having an occurrence probability of 0.001. Hence,
P(Stopwords) = 200 ∗ 0.001 = 0.2
P(non − stopwords) = 1 − 0.2 = 0.8

For maximum entropy, the remaining probability should be uniformly distributed. For every non-stopword w, P(w) = 0.8/(1200 − 200) = 0.8/1000 = 0.0008. Finally, the value of the entropy would be,

$$
\begin{aligned}
H &= E(\log(1/p)) \\
&= -200(0.001 * \log(0.001)) - 1000(0.0008 \log(0.0008)) \\
&= -200(0.001 * (-3)) - 1000(0.0008 * (-3.0969)) \\
&= 0.6 + 2.4775 \\
&= 3.0775
\end{aligned}
$$

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5. **[Marks 1]**

Suppose you have the input sentence “Sachin is a great cricketer”.
And you know the possible tags each of the words in the sentence can take.

- Sachin: NN, NNS, NNP, NNPS
- is: VB
- a: DT
- great: ADJ
- cricketer: NN, NNS, NNP

How many possible hidden state sequences are possible for the above sentence and States?

A) $4 \times 3 \times 3$
B) 3×4
C) $2^4 \times 2^3 \times 2^3$
D) 3×4^2

Answer: B

Solution: Each possible hidden sequence can take only one POS tag for each of the words. Hence the total possibility will be a product of the number of candidates for each word.

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6.

[Marks 1]

What are the time and space complexity order of the Viterbi algorithm? K is the number of states and N number of time steps.

A) KN, K^2N
B) K^2N, KN
C) K^2N, K^2N
D) KN, KN

Answer: B

Solution: The sum-product algorithm is polynomial. The time complexity is

$O(K^2N)$, the space complexity is $O(KN)$, where K is the number of states and N number of time steps.

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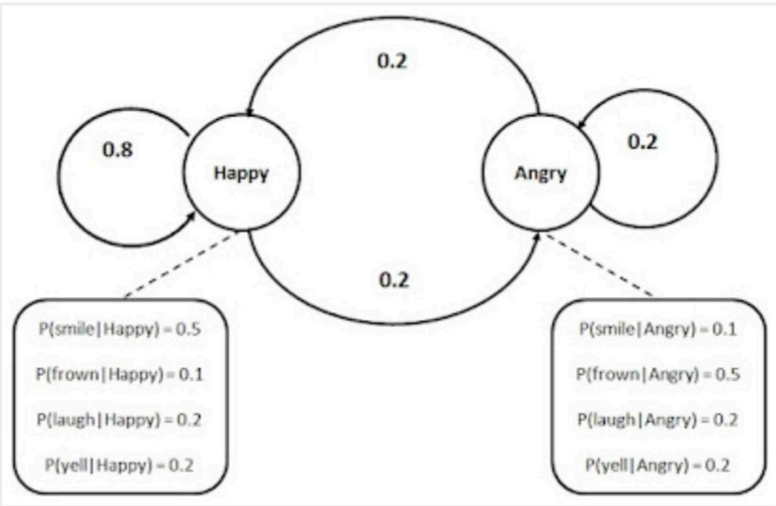
7.

[Marks 2]

Mr. X is happy someday and angry on other days. We can only observe when he smiles, frowns, laughs, or yells but not his actual emotional state. Let us start on day 1 in a happy state. There can be only one state transition per day. It can be either a happy state or an angry state. The HMM is shown below-

Assume that q_t is the state on day t and o_t is the observation on day t. Answer the following questions;



What is $P(o_2 = frown)$?

A) 0.56
B) 0.18
C) 0.03
D) 0.78

Answer: B

Solution: We need to find the probability of observation ***frown*** on day 2. But we don't know whether he is happy or not on day 2 (we know he was happy on day 1). Hence, the probability of the observation is the sum of products of observation probabilities and all possible hidden state transitions.

$P(o_2 = \text{frown}) = P(o_2 = \text{frown} \mid q_2 = \text{Happy}) + P(o_2 = \text{frown} \mid q_2 = \text{Angry})$

$= P(\text{Happy} \mid \text{Happy}) * P(\text{frown} \mid \text{Happy}) + P(\text{Angry} \mid \text{Happy}) * P(\text{frown} \mid \text{Angry})$

$= (0.8 * 0.1) + (0.2 * 0.5) = 0.08 + 0.1 = 0.18$