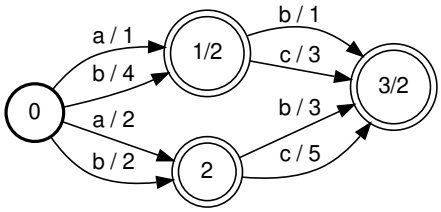
Exam of *Statistical Structured Prediction*

MIARFID, Universitat Politècnica de València, Monday, February 12, 2024

Last names: _____ **First name:** _____

Mark each box with a single option. The final score of this test is calculated as: $\max\{0, (hits - errors/3)\}$ 4.0

1 [C] Given the weighted finite-state automaton on the right and considering a probabilistic semiring, what will be the final score for $[[A]](ab)$? By convention, a bold circle represents the initial state, and double circles represent the final states. The label l and weight w of a transition are marked on the corresponding directed arc by l/w. When explicitly shown, the final weight w of a final state f is marked by f/w.



A) $[[A]](ab) = 4$
B) $[[A]](ab) = 12$
C) $[[A]](ab) = 14$
D) $[[A]](ab) = 16$

2 [D] Given a Probabilistic Context-Free Grammar, G, where $P(x;G)$ is the probability that G generates the input string x, and let $\widehat{P}(x;G)$ be the corresponding probability obtained by the Viterbi algorithm, which of these statements is true?

A) It is always true that $P(x;G) < \widehat{P}(x;G)$.
B) $P(x;G) < \widehat{P}(x;G)$ if only if x is short enough.
C) $P(x;G) = \widehat{P}(x;G)$ if only if x is long enough.
D) It is always true that $P(x;G) \geq \widehat{P}(x;G)$.

3 [B] Given the probabilistic context-free grammar on the right, what will be the probability of the highest probability tree for the input sentence `a b a`?

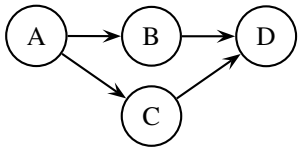
S→S A	0.2	A→a	0.2	B→a	0.5
S→A B	0.4	A→b	0.8	B→b	0.5
S→B A	0.4				

A) $8,0 \cdot 10^{-3}$
B) $6.4 \cdot 10^{-3}$
C) $1.6 \cdot 10^{-3}$
D) All trees are equiprobable.

$S \overset{0.2}{\Rightarrow} S\ A \overset{0.4}{\Rightarrow} A\ B\ A \overset{0.2}{\Rightarrow} a\ B\ A \overset{0.5}{\Rightarrow} b\ a\ A \overset{0.2}{\Rightarrow} a\ b\ a \ = 1.6 \cdot 10^{-3}$

$S \overset{0.2}{\Rightarrow} S\ A \overset{0.4}{\Rightarrow} B\ A\ A \overset{0.5}{\Rightarrow} b\ A\ A \overset{0.8}{\Rightarrow} a\ a\ A \overset{0.2}{\Rightarrow} a\ b\ a \ = 6.4 \cdot 10^{-3}$

4 [B] Given a set of random variables (A, B, C, D), which respectively take values in $(\{a_1, a_2, a_3\}, \{b_1, b_2\}, \{c_1, c_2\}, \{d_1, d_2, d_3\})$, and given the Bayesian network on the right that represents the exact factorization of the joint probability $P(A, B, C, D)$, what is the correct expression of the conditional probability $P(D = d_3 \mid A = a_1, B = b_2)$?



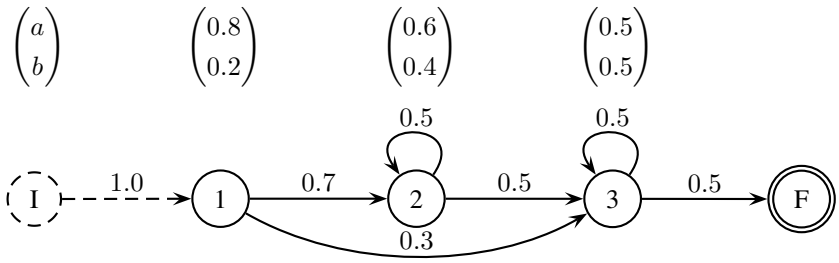
A) $\sum_{c \in \{c_1, c_2\}} P(A = a_1)\, P(B = b_2 \mid A = a_1)\, P(C = c \mid A = a_1)\, P(D = d_3 \mid B = b_2, C = c)$
B) $\sum_{c \in \{c_1, c_2\}} P(C = c \mid A = a_1)\, P(D = d_3 \mid B = b_2, C = c)$
C) $P(A = a_1)\, P(B = b_2 \mid A = a_1)\, P(C = c \mid A = a_1)\, P(D = d_3 \mid B = b_2, C = c) \,/\, P(A = a_1, B = b_2)$
D) $\sum_{c \in \{c_1, c_2\}} P(C = c \mid A = a_1)\, P(D = d_3 \mid B = b_2, C = c) \,/\, P(A = a_1, B = b_2)$

5 [A] Given the definition of score α of Forward algorithm for Conditional Random Fields, which of these statements is true?

$$\alpha_t(s) \overset{\text{def}}{=} \sum_{y_1^t;\, y_t = s} \prod_{i=1}^{t} \Psi_i\,(y_{i-1},\ y_i,\ x_i)$$

A) The final score for x is $\sum_s \alpha_T(s)$.
B) The final score for x is $\max_s \alpha_T(s)$.
C) The final score for x is $\sum_s \prod_{t=1}^{t} \alpha_T(s)$
D) The final score for x is $\max_s \prod_{t=1}^{t} \alpha_T(s)$

6 D Let M be the following Hidden Markov Model and given the string aba:



The value of $\beta_0(I)$ computed with the *backward* algorithm is

A) 0.015 B) 0.028 C) 0.058 D) 0.043

7 C If the previous HMM is estimated with the *forward-backward* algorithm with the sample $\{ab, aba\}$ with one iteration then the transition probability $1 \to 2$ becomes

A) 0.15 B) 0.0 C) 0.83 D) 1.0

8 A If the HMM two questions above is estimated with the *Viterbi* algorithm with the sample $\{aba, bab\}$ with one iteration then choose the correct answer

A) None emision probabilities become null
B) Some emision probabilities become null
C) All emision probabilities in state 1 become null
D) None of the previous answers

9 B If the HMM two questions above is estimated with the sample $\{ab, ba\}$ with one iteration then choose the correct answer

A) The *Viterbi* algorithm and the *forward-backward* algorithm do not produce the same estimated HMM.
B) The *Viterbi* algorithm and the *forward-backward* algorithm produce the same estimated HMM.
C) The *forward-backward* can not be used with this sample
D) None of the previous answers

10 C Given the PCFG G with these two rules $\{0.5\ S \to S\ S,\ 0.5\ S \to a\}$, the *outside* probability $f(S, 1, 1)$ of the string aaa is:

A) .063
B) .250
C) .125
D) .900