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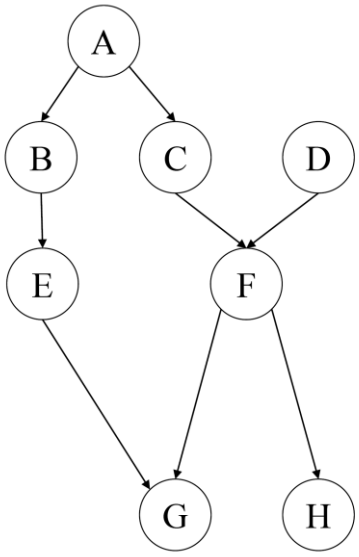
CS331: Introduction to Artificial Intelligence
Written Assignment #4

Date handed out: May 17, 2021
Date due: May 24, 2021 at 10am
Total: 25 points

The written portion of this assignment is to be done individually. Please hand in pdf on Canvas.

1. Consider the Bayesian network below. Answer false or true for the following questions on d-separation. Show the blocked paths for partial credit.



a) I (A, H | { }) [2 points]

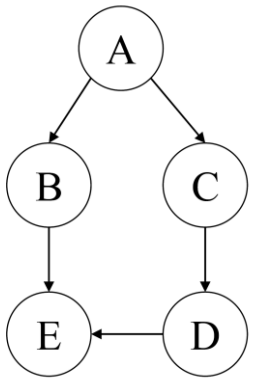
b) I (B, F | A) [2 points]

c) I (B, D | {F, G}) [2 points]

d) I (A, D | { }) [2 points]

e) I (A, D | {B, H}) [2 points]

2. Calculate the following probabilities using the Bayesian network below. The CPTs for each node are shown below the network. You may need to use the various probability formulas such as marginalization, the chain rule, conditional independence, Bayes rule, etc.



Conditional probability tables are given below:

A	P(A)
true	0.4
false	0.6

A	B	P(B|A)
true	true	0.9
true	false	0.1
false	true	0.25
false	false	0.75

C	D	P(D|C)
true	true	0.75
true	false	0.25
false	true	0.9
false	false	0.1

B	D	E	P(E|B,D)
true	true	true	0.1
true	true	false	0.9
true	false	true	0.2
true	false	false	0.8
false	true	true	0.3
false	true	false	0.7
false	false	true	0.4
false	false	false	0.6

A	C	P(C|A)
true	true	0.25
true	false	0.75
false	true	0.8
false	false	0.2

a) P(A=true, B=false, C=true, D=false, E=true) [5 points]

b) P(B=false, C=true) [5 points]

c) P(A=true | B=false, C=true) [5 points]

1. (a) A C F H Unblocked

A B E G F H blocked by G (case 3)

G is not in evidence set

∴ No

(b) B E G F blocked by A (case 1)

B A C F blocked by G (case 3)

G is not in evidence set

∴ Yes

(c) B A C F D Unblocked

B E G F D blocked by F (case 2)

∴ No

(d) A C F D blocked by F (F not in evidence set) (case 3)

A B E G F D blocked by G (G not in evidence set) (case 3)

∴ Yes.

(e) A C F D Unblocked

A B E G F D blocked by G (G not in evidence set) (case 3)

∴ No.

2. (a) $P(A=T, B=F, C=T, D=F, E=T)$

$= P(A) P(B|A) P(C|A) P(D|C) P(E|B,D)$

$= 0.4 \times 0.1 \times 0.25 \times 0.25 \times 0.4$

$= \boxed{0.001}$

(b) $P(B=F, C=T)$

$= \sum_a \sum_d \sum_e P(A=a, B=F, C=T, D=d, E=e)$

$= \sum_a \sum_d \sum_e P(A=a) P(B=F|A=a) P(C=T|A=a) P(D=d|C=T) P(E=e|B=F, D=d)$

$= \sum_a \left[P(A=a) P(B=F|A=a) P(C=T|A=a) \sum_d \left[P(D=d|C=T) \sum_e \left[P(E=e|B=F, D=d) \right] \right] \right]$

$= \sum_a \left[P(A=a) P(B=F|A=a) P(C=T|A=a) \right]$ (the inner $\sum_e$ term equals 1, and the $\sum_d$ term equals 1)

$= (0.4 \times 0.1 \times 0.25) + (0.6 \times 0.75 \times 0.8)$

$= 0.01 + 0.36 = \boxed{0.37}$

(c) $P(A=T \mid B=F, C=T)$

$$= \frac{P(A=T, B=F, C=T)}{P(B=F, C=T)}$$

$$= \frac{\sum_d \sum_e P(A=T, B=F, C=T, D=d, E=e)}{\sum_a \sum_d \sum_e P(A=a, B=F, C=T, D=d, E=e)}$$

$$\sum_d \sum_e P(A=T)\,P(B=F \mid A=T)\,P(C=T \mid A=T)\,P(D=d \mid C=T)\,P(E=e \mid B=F, D=d)$$

$$= \frac{\sum_a \sum_d \sum_e P(A=a)\,P(B=F \mid A=a)\,P(C=T \mid A=a)\,P(D=d \mid C=T)\,P(E=e \mid B=F, D=d)}{P(A=T)\,P(B=F \mid A=T)\,P(C=T \mid A=T)\sum_d \left[P(D=d \mid C=T) \sum_e \left[P(E=e \mid B=F, D=d)\right]\right]}$$

$$= \frac{}{\sum_a \left[P(A=a)\,P(B=F \mid A=a)\,P(C=T \mid A=a) \sum_d \left[P(D=d \mid C=T) \sum_e \left[P(E=e \mid B=F, D=d)\right]\right]\right]}$$

$$= \frac{P(A=T)\,P(B=F \mid A=T)\,P(C=T \mid A=T)}{0.037} \leftarrow \text{(This is from Part b)}$$

$$= \frac{0.4 \times 0.1 \times 0.25 = 0.01}{0.037} \approx 0.27027\ldots$$