CS486: Assignment 2

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Q2 b)

Question 2

a)

- Acc – card holder has an account with the merchant for current transaction.
- $Fraud$ – current transaction is fraudulent.
- $Trav$ – card holder is currently traveling.
- FP – current transaction is a foreign purchase.
- OP – current purchase is an online purchase.
- PT – previous transaction with the same merchant was made in the past week.

Probabilities:

- $P(Fraud|Trav) = 0.01$: Probability of a fraudulent transaction when the card holder is traveling.
- $P(Fraud|\neg Trav) = 0.004$: Probability of a fraudulent transaction when the card holder is not traveling.
- $P(Trav) = 0.05$: Probability of the card holder traveling.
- $P(FP|Fraud, \neg Trav) = 0.1$: Probability of a foreign purchase for a fraudulent transaction when the card holder is not traveling.
- $P(FP|Fraud, Trav) = 0.9$: Probability of a foreign purchase for a fraudulent transaction when the card holder is traveling.

- $P(FP|\neg Fraud, \neg Trav) = 0.01$: Probability of a foreign purchase for a legitimate transaction when the card holder is not traveling.
- $P(FP|\neg Fraud, Trav) = 0.9$: Probability of a foreign purchase for a legitimate transaction when the card holder is traveling.
- $P(OP|Acc, \neg Fraud) = 0.6$: Probability of an online purchase when the card holder has an account with the merchant and the transaction is legitimate.
- $P(OP|Acc, Fraud) = 0.8$: Probability of an online purchase when the card holder has an account with the merchant and the transaction is fraudulent.
- $P(OP|\neg Acc, \neg Fraud) = 0.1$: Probability of an online purchase when the card holder doesn't have an account with the merchant and the transaction is legitimate.
- $P(OP|\neg Acc, Fraud) = 0.3$: Probability of an online purchase when the card holder doesn't have an account with the merchant and the transaction is fraudulent.
- $P(PT|Acc) = 0.1$: Probability of a previous transaction with the same merchant in the past week, given that the card holder has an account with the merchant.
- $P(PT|\neg Acc) = 0.01$: Probability of a previous transaction with the same merchant in the past week, given that the card holder doesn't have an account with the merchant.

Conditional Probability tables

Factor 1: $f_1(Trav)$

$P(Trav)$	
$False$	0.95
$True$	0.05

Factor 2: $f_2(Fraud|Trav)$

$Trav$	$P(Fraud) = False$	$P(Fraud) = True$
$False$	0.996	0.004
$True$	0.99	0.01

Factor 3: $f_3(FP|Fraud, Trav)$

$Fraud$	$Trav$	$P(FP) = False$	$P(FP) = True$
$False$	$False$	0.99	0.01
$False$	$True$	0.1	0.9
$True$	$False$	0.9	0.1
$True$	$True$	0.1	0.9

Factor 4: $Pr(PT|Acc)$

Acc	$P(PT) = False$	$P(PT) = True$
$False$	0.99	0.01
$True$	0.9	0.1

Factor 5: $Pr(OP|Acc, Fraud)$

Acc	$Fraud$	$P(OP) = False$	$P(OP) = True$
$False$	$False$	0.9	0.1

$False$	$True$	0.7	0.3
$True$	$False$	0.4	0.6
$True$	$True$	0.2	0.8

Factor 6: $f_6(Acc)$

$P(Acc)$	
$False$	0.2
$True$	0.8

2 b)

Prior probability of fraud:

$$\begin{aligned} P(Fraud) &= P(Fraud|Trav) * P(Trav) + P(Fraud|\neg Trav) * P(\neg Trav) \\ &= (0.01 * 0.05) + (0.004 * (1 - 0.05)) \\ &= 0.0005 + 0.0038 \\ &= 0.0043 \end{aligned}$$

New factors after the evidence

$$f_7(FP = true|Fraud, Trav)$$

$$f_8(OP = false|Acc, Fraud)$$

$$f_9(PT = true|Acc)$$

2 b)

The table for f_{10}

$$f_{10}(Fraud) = \sum_{Trav} f_1(Trav) f_2(Fraud|Trav) f_7(FP = true|Fraud, Trav)$$

Fraud	$f_{10}(\text{Fraud})$
0	0.9848656139455163
1	0.015134386054483789

$$f_{11}(Fraud) = \sum_{Acc} f_6(Acc) f_8(OP = false|Acc, Fraud) f_9 = Pr(PT = true|Acc)$$

The table for f_{11}

Fraud	$f_{11}(\text{Fraud})$
0	0.6659007352941176
1	0.33409926470588236

$$querry_{final}(Fraud) = f_{10}(Fraud) f_{11}(Fraud)$$

The final table

Fraud	$\text{query}_{\text{factor}}(\text{Fraud})$
0	0.9923489983706452
1	0.007651001629354852

$$P(Fraud|FP, \neg OP, PT) = f_{10}(Fraud)f_{11}(Fraud) = querry_{final}(Fraud)$$

$$query_{factor}(\neg Fraud) = 0.007651$$

2 c)

If the card holder is not home than travelling is evidence. Thus we need to add Travelling into the evidence list. We are now asking:

> 💡 What is the probability of fraud GIVEN foreign purchase, online purchase, past purchase and travelling.

The following is the calculations for the probability.

$$f_{12}(Fraud) = \sum_{Acc} f_6(Acc)f_8(OP = false|Acc, Fraud)f_9(PT = true|Acc)$$

Fraud	$f_{12}(\text{Fraud})$
0	0.6659007352941176
1	0.33409926470588236

$$P(Fraud|FP, \neg OP, PT, Trav) = query_{factor}(Fraud) = f_1(Trav = true)f_2(Fraud|Trav = true)f_7(FP = true|Fr$$

Fraud	$\text{query}_{\text{factor}}$
0	0.9949576218285731
1	0.005042378171426986

$$P(Fraud|FP, \neg OP, PT, Trav) = 0.00504...$$

2 c)

From my assumptions there are evidence for an online purchase $OP = true$.

If I do not care about anything else my probability of fraud is:

$$P(Fraud|OP) = 0.00600966$$

I should not be travelling and I should make a domestic purchase.

I should make an account with a merchant

$$P(Fraud|OP, \neg Trav, \neg FP, Acc, PT) = 0.00484437$$

There are no paths from Past transactions thus

Overall the probability of fraud gets reduced by 0.2 percent

Question 3

a. Suppose a mechanics would like to know what components may influence the functioning of other components. Answer the following questions and give a bird justification based on the D-separation rules.

   i. D and G are not independent they are as there exist a direct connection from D and G

   ii. D and G is not independent given F as there exist a directed connection between them.

   iii. A and G is independent as there is no path that connects them

iv. A and G is not independent given B as evidence to B connects A and C by rule 3. C is dependent of F by rule 2 as D is not in evidence. Since there is a path connecting F and G. A and G is not independent.

v. A and G is independent as the evidence of C is blocking the path by rule 2

vi. A and G is independent as the path from C to F, G is blocked according to rule $2, 3$

vii. A and G is not independent as the path from A and C is unblocked by rule 3. C and F is blocked and unblocked by rule 2 and 3 however in this case there still one path thus A and G is dependent

b. We just need to look at D, F. C is dependent on$D$ as there is a direct connection. There is a connection from F to C by rule 3 .