



Workshop 12

COMP90051 Machine Learning

Semester 1, 2023

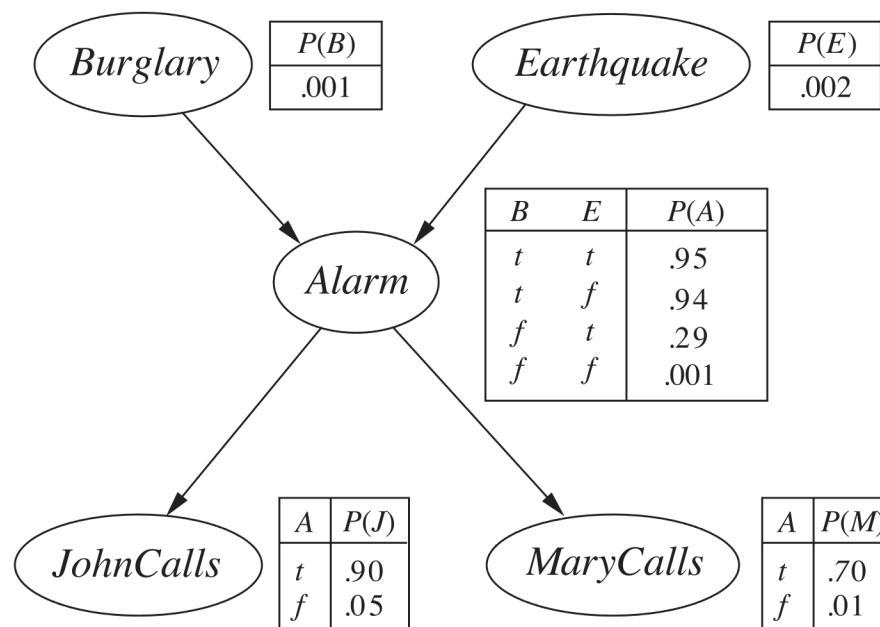
Learning Outcomes

By the end of this workshop you should be able to:

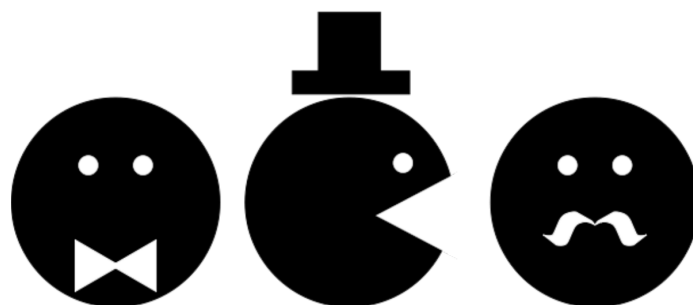
1. answer probabilistic queries on simple directed PGMs by **variable elimination**
2. explain why **variable elimination** order affects the efficiency of inference on directed PGMs
3. specify a **PGM** based on a natural language description

Exercise 1

- Leo's house has an alarm to detect burglars
- The alarm is occasionally set off by an earthquake
- Leo's neighbours John and Mary (who don't know each other) sometimes call if they hear the alarm
- If Leo receives a call from John and Mary, what's the likelihood his house has been burgled?



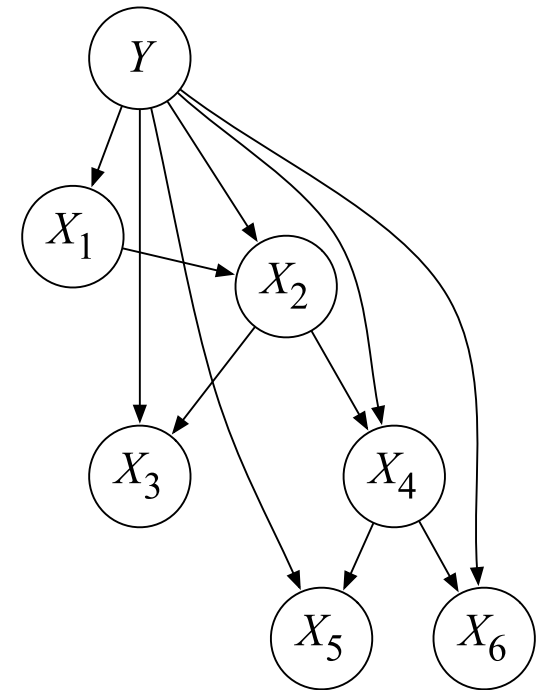
Exercise 2



- Pacbaby's parents are trying to teach her to discriminate between Pacmen ($Y = 1$) and ghosts ($Y = -1$)
- She will use visual features such as presence of bowtie, hat, moustache etc., denoted by X_1, X_2, \dots, X_6
- The features are *not independent*, so Pacbaby's parents decide to use a tree-augmented Naïve Bayes (TANB) model

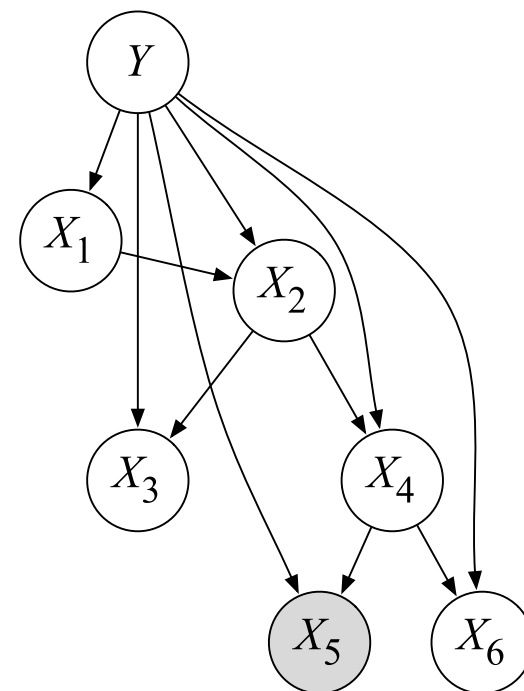
Q2a: TANB model

Assume all features $\mathbf{X} = (X_1, \dots, X_6)$ are observed. What is the classification rule? Your answer should be in terms of the conditional distributions.



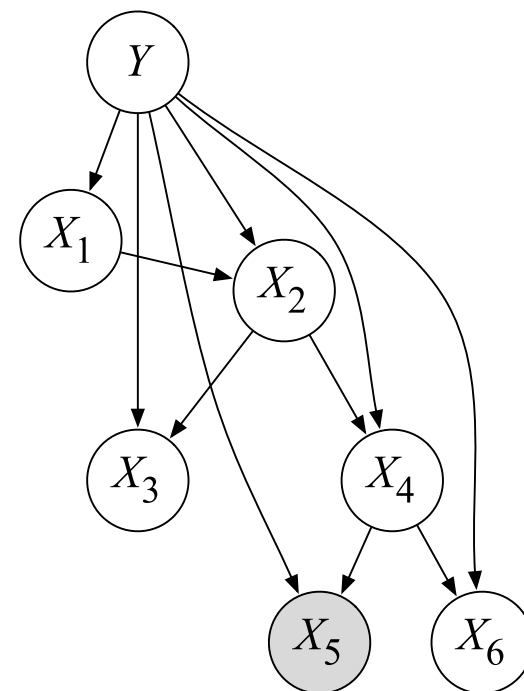
Q2b: Efficient variable elimination

Specify an efficient elimination order for the query $p(Y|X_5 = x_5)$. How many variables are in the biggest factor induced by variable elimination? Which variables are they?



Q2c: Efficient variable elimination

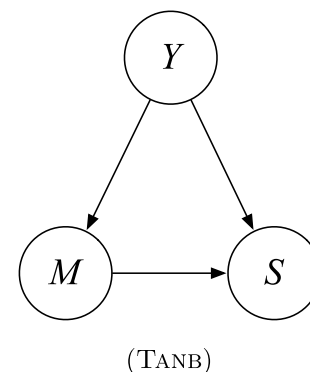
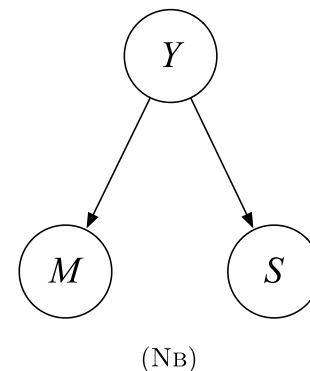
Specify an efficient elimination order for the query $p(X_3 | X_5 = x_5)$. How many variables are in the biggest factor induced by variable elimination? Which variables are they?



Exercise 3

Use the following facts to fill out the conditional probability tables for the NB and TANB models:

- Pacbaby observes $Y = 1$ or $Y = -1$ 50% of the time
- Given $Y = 1$, Pacbaby observes $M = 1$ (moustache) 50% of the time and $S = 1$ (sunglasses) 50% of the time
- When Pacbaby observes $Y = -1$, the frequency of observations are identical (equal probabilities of $M = 1, -1$ and $S = 1, -1$)
- When Pacbaby observes $Y = 1$, anyone with a moustache wears sunglasses and anyone without a moustache does not wear sunglasses
- If $Y = -1$ the presence/absence of a moustache has no influence on sunglasses



Q3a: CPTs

NB model

$P(Y = y)$	
$y = 1$	$y = -1$

$P(M = m Y = y)$		
y	$m = 1$	$m = -1$
1		
-1		

$P(S = s Y = y)$		
y	$s = 1$	$s = -1$
1		
-1		

TANB model

$P(Y = y)$	
$y = 1$	$y = -1$

$P(M = m Y = y)$		
y	$m = 1$	$m = -1$
1		
-1		

$P(S = s Y = y, M = m)$			
y	m	$s = 1$	$s = -1$
1	1		
-1	1		
1	-1		
-1	-1		

Q3b: Query

Pacbaby sees someone with a moustache wearing a pair of sunglasses.

What prediction does the NB model make? What probability does it assign to its prediction?

Q3b: Query

Pacbaby sees someone with a moustache wearing a pair of sunglasses.

What prediction does the TANB model make? What probability does it assign to its prediction?