

# CS325 Artificial Intelligence

## Chs 13–14 Notes

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# Probability Cheat Sheet

Summation rule:  $P(A) + P(\neg A) = 1$

Non-binary:  $\sum_x P(A = x) = 1$

Union:  $P(A \vee B) = P(A) + P(B) - P(A \wedge B)$

Conditional and joint prob:

$$P(A|B) P(B) = P(A, B)$$

$$P(B|A) P(A) = P(A, B)$$

Bayes rule:

$$P(B|A) = \frac{P(A|B) P(B)}{P(A)}$$

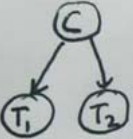
Normalize instead of  $P(A)$ :

$P(A) = P(A|B) P(B) + P(A|\neg B) P(\neg B)$  because  
 $P(B|A) + P(\neg B|A) = 1$ .

In general:  $P(A|X) = \alpha \sum_y P(A, X, y)$

# Cancer Example with 2 Tests

2-TEST CANCER EXAMPLE



$P(C) = 0.01$        $P(\neg C) = 0.99$   
 $P(+|C) = 0.9$        $P(-|C) = 0.1$   
 $P(-|\neg C) = 0.8$        $P(+|\neg C) = 0.2$

$P(C | T_1 = + T_2 = +) = P(C | ++)$  =

Independence:

$$\begin{aligned}X \perp Y &\Rightarrow P(X|Y) = P(X) \\ &\Rightarrow P(X, Y) = P(X)P(Y)\end{aligned}$$

Conditional ind:

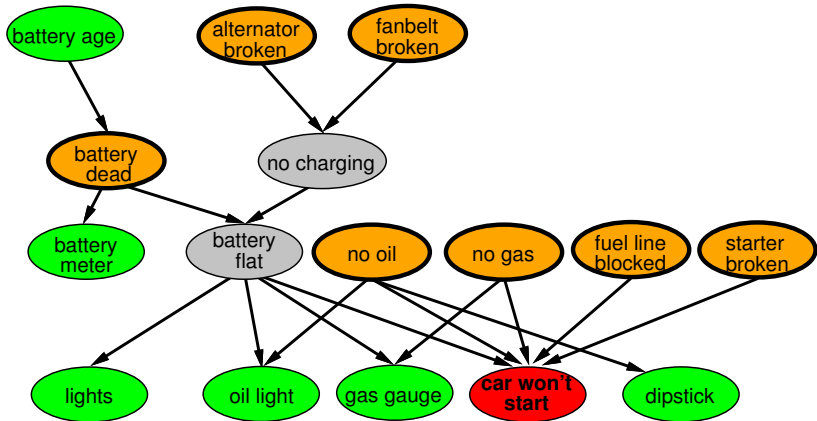
$$X \perp Y|Z \Rightarrow P(X|Z, Y) = P(X|Z)$$

Exercises

$$X \perp Y|Z \Leftrightarrow P(X \perp Y)?$$

- Explaining away?
- Dependence based on outcome:  
 $P(C|A, B) \Rightarrow A \perp B$  but not  $A \perp B|C$
- More complex Bayes nets
  - D-separation (reachability); summary of rules
  - joint probability, number of parameters?
  - compactness based on construction

# Car diagnosis

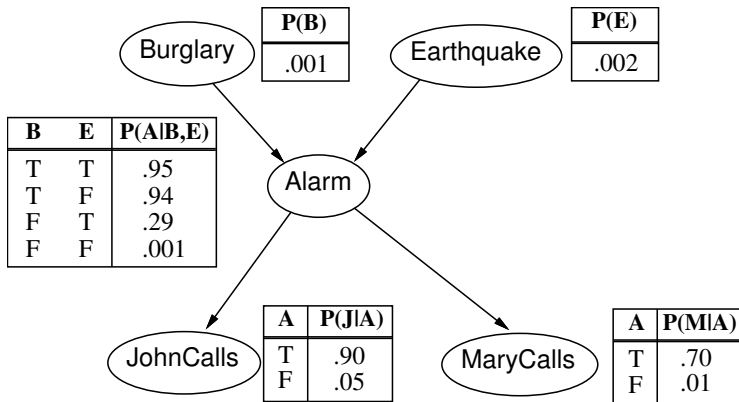


Number of params?

# Continuous random variables?

- Natural values
- Discretization
- Hybrid Bayes nets
- Sigmoid and Gaussian
- Fuzzy logic

# Burglary or Earthquake?





# Burglary or Earthquake?

Bayesian network diagram showing the relationships between variables:

- Burglary and Earthquake are parents of Alarm.
- Alarm is the parent of John calls and Mary calls.

Probability tables for the variables:

B	P(B)
+b	0.001
-b	0.999

E	P(E)
+e	0.002
-e	0.998

A	J	P(J A)
+a	+j	0.9
+a	-j	0.1
-a	+j	0.05
-a	-j	0.95

A	M	P(M A)
+a	+m	0.7
+a	-m	0.3
-a	+m	0.01
-a	-m	0.99

B	E	A	P(A B,E)
+b	+e	+a	0.95
+b	+e	-a	0.05
+b	-e	+a	0.94
+b	-e	-a	0.06
-b	+e	+a	0.29
-b	+e	-a	0.71
-b	-e	+a	0.001
-b	-e	-a	0.999

Handwritten formula:

$$P(+b) P(+e) P(+a|+b,+e) P(+j|+a) P(+m|+a)$$