

# CS 188 SECTION 7

# ABOUT ME

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- Daylen Yang
- [daylen@berkeley.edu](mailto:daylen@berkeley.edu) (but use Piazza!)
- Sections MW 4-5pm in 310 Soda
- Office Hours Thursdays 4-6pm in 411 Soda

# UPCOMING DEADLINES

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- HW 3 due **tonight** @ 11:59
- Project 3 due **Friday** 7/15 @ 5pm
- Contest 2 due **Sunday** 7/17 @ 11:59

# BAYES NETS

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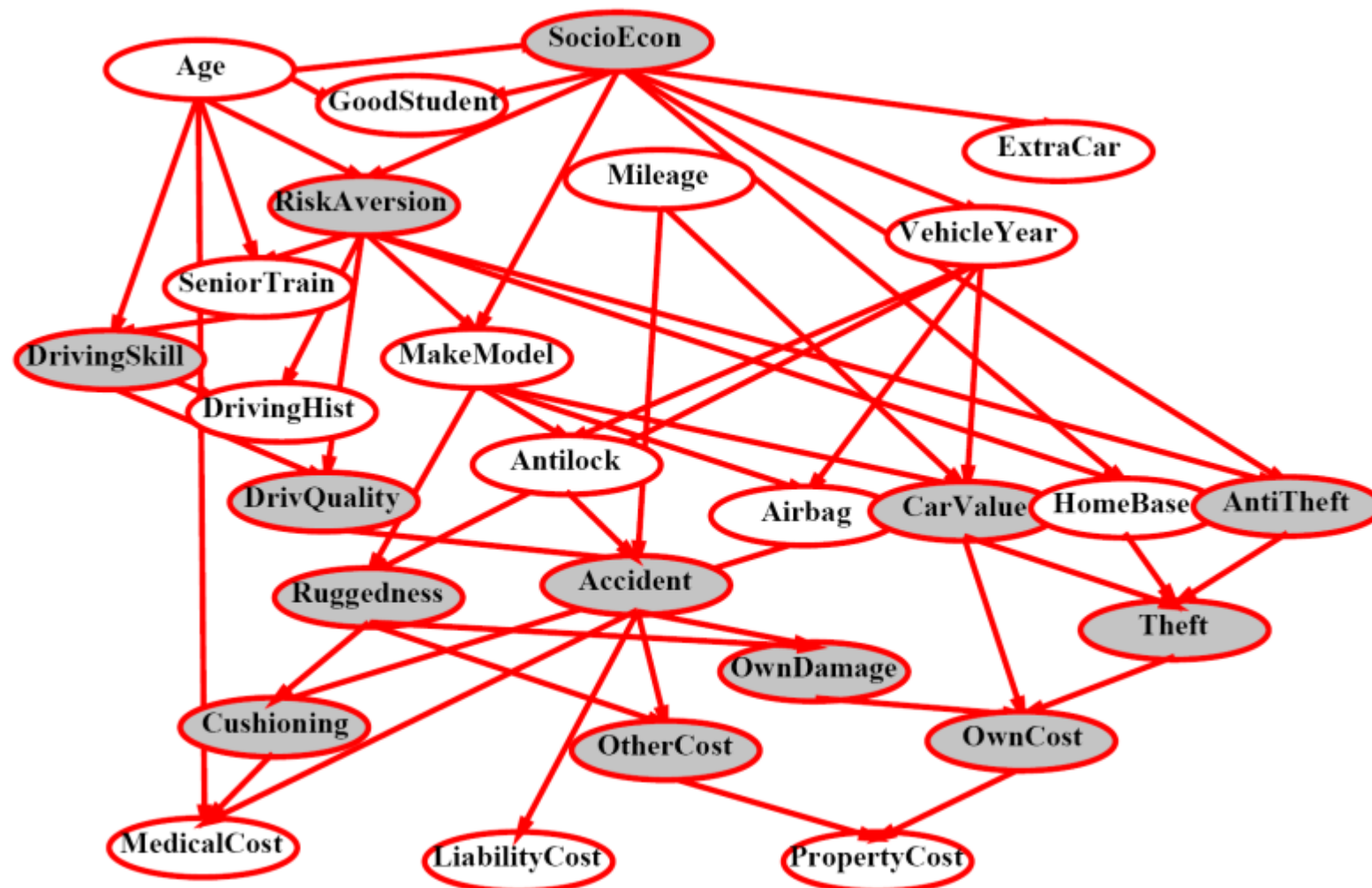
- Representation – yesterday
- Independence – today
- Inference – tomorrow
- Sampling – Monday

# REPRESENTATION

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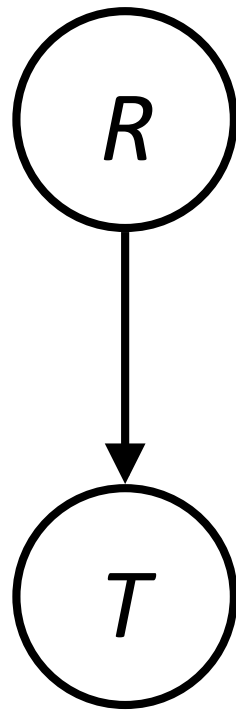
- **Motivation:** way to describe a joint distribution using simpler local distributions (conditional probabilities)

$$O(2^N) \text{ vs } O(N \cdot 2^{k+1})$$



# REPRESENTATION

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$P(R)$

+r	1/4
-r	3/4

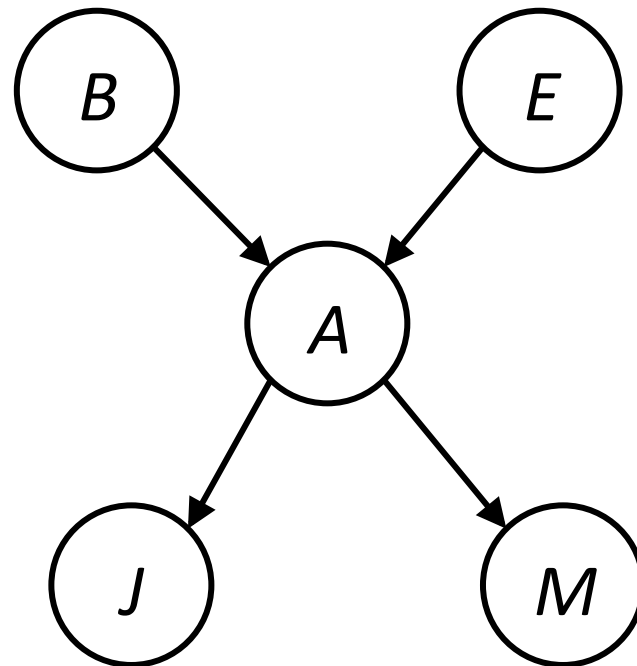
$P(T|R)$

+r	+t	3/4
	-t	1/4
-r	+t	1/2
	-t	1/2

$$P(+r, -t) =$$

# REPRESENTATION

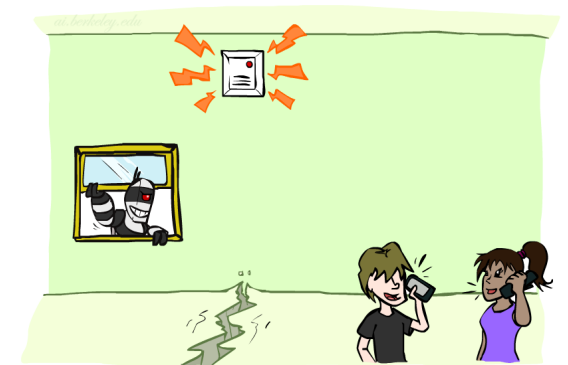
B	P(B)
+b	0.001
-b	0.999



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

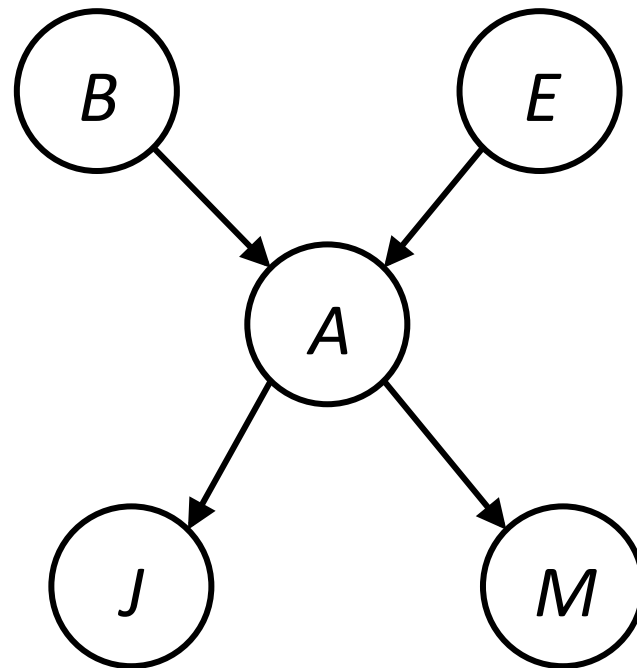


B	E	A	P(A B,E)
+b	+e	+a	0.95
+b	+e	-a	0.05
+b	-e	+a	0.94
+b	-e	-a	0.06
-b	+e	+a	0.29
-b	+e	-a	0.71
-b	-e	+a	0.001
-b	-e	-a	0.999

$$P(+b, -e, +a, -j, +m) =$$

# REPRESENTATION

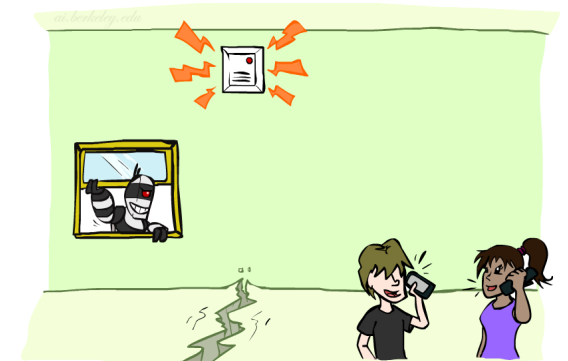
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+b	-e	-a	0.06
-b	+e	+a	0.29
-b	+e	-a	0.71
-b	-e	+a	0.001
-b	-e	-a	0.999

$$\begin{aligned}
 P(+b, -e, +a, -j, +m) &= \\
 P(+b)P(-e)P(+a|+b, -e)P(-j|+a)P(+m|+a) &= \\
 0.001 \times 0.998 \times 0.94 \times 0.1 \times 0.7 &
 \end{aligned}$$



# INDEPENDENCE

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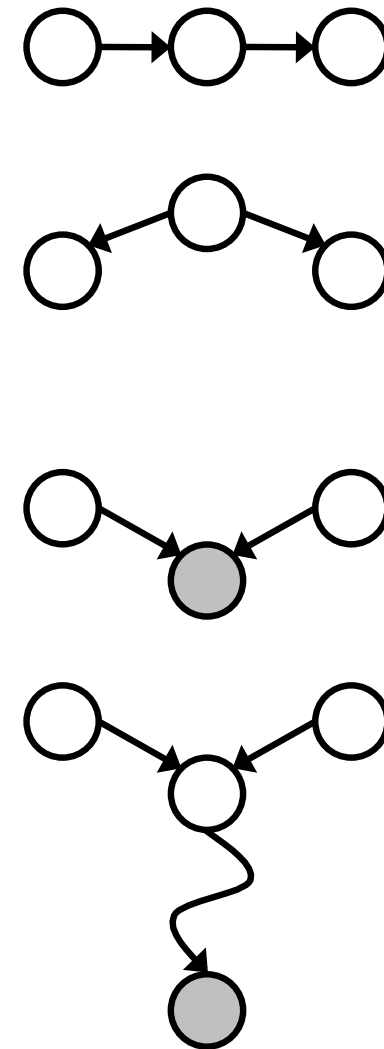
- **Question:** Are two nodes independent given certain evidence?
- **Technique to solve: D-separation**

# INDEPENDENCE

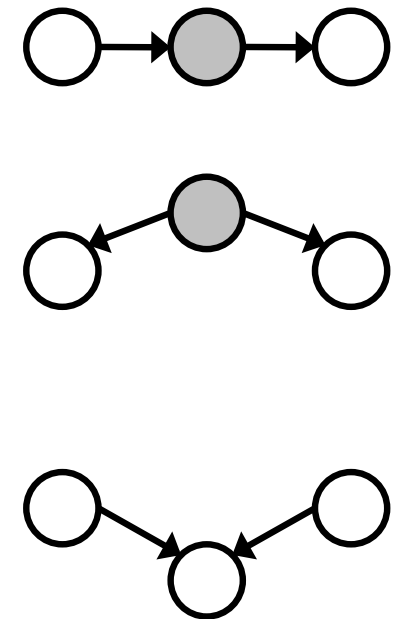
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- Question: Are X and Y conditionally independent given evidence variables {Z}?
  - Yes, if X and Y “d-separated” by Z
  - Consider all (undirected) paths from X to Y
  - No active paths = independence!
- A path is active if each triple is active:
  - Causal chain  $A \rightarrow B \rightarrow C$  where B is unobserved (either direction)
  - Common cause  $A \leftarrow B \rightarrow C$  where B is unobserved
  - Common effect (aka v-structure)  
 $A \rightarrow B \leftarrow C$  where B or one of its descendants is observed
- All it takes to block a path is a single inactive segment

Active Triples



Inactive Triples



**WORKSHEET**

# INFERENCE (PREVIEW)

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- We want to... compute some useful quantity from a Bayes Net
- Two methods:
  - Enumeration (naive)
  - Variable elimination (faster)