

# ROB311 Quiz 2

Hanhee Lee

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# Probabilistic Inference Problems

## 1 Probability Review

### 1.1 Bayesian Network

**Definition:** Vertices represent random variables and edges represent dependencies between variables.

#### 1.1.1 Junction

**Definition:** A **junction** consists of three vertices,  $X_1$ ,  $X_2$ , and  $X_3$ , connected by two edges,  $e_1$  and  $e_2$ :

- Both arrows pointing in one direction
- Both arrows pointing in opposite directions
- One arrow pointing in each direction

**Warning:** Want to look for causal relationships. Arrows, what's causing what, what's influencing what.

#### 1.1.2 Causal Chain

**Definition:** A causal chain is a junction of the following form:

- $X_1$  and  $X_2$  are dependent.  $X_2$  is dependent on  $X_1$ . Vice versa. From a causal perspective,  $X_1$  is influencing  $X_2$ . Subtle difference, just bc  $X_1 \rightarrow X_2$ .
- $X_2$  and  $X_3$  are dependent.
- $X_1$  and  $X_3$  are dependent.
  - Given  $X_2$ ,  $X_1$  and  $X_3$  are independent. Why?  $X_2$ 's door closes when you know  $X_2$ , so  $X_1$  and  $X_3$  are independent.

**Warning:**  $X_1$  is influencing  $X_2$  and  $X_2$  is influencing  $X_3$ .

#### 1.1.3 Common Cause

**Definition:** A common cause is a junction of the form:

**Notes:**

- $X_1$  and  $X_3$  are dependent.
  - Given  $X_2$ ,  $X_1$  and  $X_3$  are independent. Why?  $X_2$  whether you smoke or not,  $X_1$  whether you have yellow teeth,  $X_3$  whether you have lung cancer, if you don't know  $X_2$ , if they have yellow teeth, then they might smoke, then they might have lung cancer. If you know  $X_2$ , yellow teeth and lung cancer are independent b/c you already know if they smoke or not, and yellow teeth implies smoke,

#### 1.1.4 Common Effect

**Definition:** A common effect is a junction of the form:

**Notes:**

- $X_1$  and  $X_3$  are independent.
- Given  $X_2$  or any of  $X_2$ 's descendants,  $X_1$  and  $X_3$  are dependent.

**Warning:** Just b/c you don't know something about the middle variable, then it can be independent

**Example:**  $X_2$  Grass being wet,  $X_1$  raining, and  $X_3$  sprinkler being on.

- If you know the grass is wet, you know that either the sprinkler is on or it's raining.
  - If it didn't have the sprinkler on, then it must have rained.
  - If it didn't rain, then the sprinkler must have been on.
  - So this means that  $X_1$  and  $X_3$  are dependent given  $X_2$ .
- If you don't know the grass is wet, then  $X_1$  and  $X_3$  are independent b/c you don't know if it rained or the sprinkler was on.

**Example:**

1. **Given:** Caveman is deciding whether to go hunt for meat. He must take into account several factors:

- Weather
- Possibility of over-exertion
- Possibility encountering lion

These factors can result in Cavemen's death. His decision will ultimately depend on the **chances** of his death.

2. **Binary Variables:**

- $W = \{\text{Sun, Rainy}\}$ : Weather
- $H$ : Whether the Cavemen goes hunting or not.
- $L$ : Whether the Cavemen encounters a lion or not.
- $T$ : Whether the Cavement is tired or not.
- $D$ : Whether the Cavemen dies or not

3. **Problem:** Cavemen must decide whether to go hunting or not.

- He must consider the conditional probabilities (i.e. dependence) of each event.

**Warning:** Have to be discrete.