CHAPTER 14.1-3

BAYESIAN NETWORKS
Bayesian networks

As a simple, graphical notation for conditional independence assertions
and hence for compact specifications of full joint distributions

Syntax:

A directed, acyclic graph (link "directly influences")

In the simplest case, conditional distribution represented as

\[ P(X_i | \text{Parents}(X_i)) \]

A conditional probability table (CPT) giving the

distribution over \( X_i \) for each combination of parent values.
Example

Topology of network encodes conditional independence assertions:

- Weather is independent of the other variables.
- Toothache and Catch are conditionally independent given Cavity.
Example

I'm at work, neighbor John calls to say my alarm is ringing, but neighbor Mary doesn't call. Sometimes it's set off by minor earthquakes. Is there a burglar?

Network topology reflects "causal" knowledge:

- The alarm can cause John to call
- The alarm can cause Mary to call
- An earthquake can set the alarm off
- A burglar can set the alarm off

Variables: Burglar, Earthquake, Alarm, JohnCalls, MaryCalls

burglar

Mary doesn't call. Sometimes it's set off by minor earthquakes. Is there a burglar?
Example contd.
Each node is conditionally independent of all others given its Markov blanket: parents + children + children’s parents.

Markov blanket
Suppose we choose the ordering $M,J,A,B,E$. The network is as follows:
Bayes nets provide a natural representation for (causally induced) conditional independence. Traditionally, variables are discrete, e.g., binary, and each variable has a parameterized distribution (e.g., Bernoulli or Gaussian) that is defined by parameters. Continuous variables can be handled by using appropriate parameterizations, such as linear Gaussian distributions.

Topological structure (i.e., graph) + parameters = compact representation of joint distribution. Generally easy for (non)experts to construct and generally naturally induce conditional independence.

Canonical distributions (e.g., noisy-OR) = compact representation of CPTs. Generally easy for (non)experts to construct.