

Everything on Bayesian Belief Networks

A Bayesian (BN) is a way of describing the relationships between causes and effects, and is made up of nodes and arcs

Nodes: Random variables

Arcs: Casual or influential relationships

Uncertainty

Can be caused by:

1. Noise
2. Partial knowledge
3. Random phenomena

Measure with probability

Propositional Logic

Statements are indivisible units.

Probability

A random variable is a variable which represents a random event

SUM RULE

$$P(A \text{ or } B) = P(A \cup B) = P(A) + P(B) \quad \text{with } A, B \text{ disjoint}$$

$$P(A \text{ or } B) = P(A) + P(B) - P(A \cap B) \quad \text{otherwise}$$

Product Rule (For Dependent Events)

$$P(X = A, Y = A) = P(X = A | Y = A) * P(Y = A)$$

Product Rule (Independent Events)

$$P(X, Y) = P(X)P(Y), \quad \text{ie.} \quad P(X|Y) = P(X)$$

Conditional Probability

The probability of an event (X), given that another (Y) has already occurred.

Conditional probability of X given Y $\rightarrow P(X|Y)$

Bayes' Theorem (Conditional Probability)

$$P(X|Y) = \frac{P(Y|X)P(X)}{P(Y)}$$

Important:

$$P(A \cup B) = P(B \cup A)$$

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

$$P(A|B) \neq P(B|A)$$

Independent Events:

If the knowledge about Y does not change the probability of X then the two events are said to be independent.

Bayesian Belief Networks (BBN)

Structure

- Random variables are depicted as nodes
- Arcs represent probabilistic dependence between variables

When a node is set, the information propagates through the network

Construction

1) Feature extraction

Involves reading the problem and calculating the probabilities out of the given data

2) Construction

1. Top-level nodes - don't have any probabilistic dependency, could be seen as observations
2. Dependency relationships - describe the interpretation of dependencies in the model.

The structure must be acyclic, this guarantees efficient propagation algorithms

3) Use of the BBN

Use the network to determine new information

Things to Remember

1. If you know parent information and want to find child information, use conditional probability
2. If you know child information and want to find parent information, use bayes theorem
3. If you have more than 1 parent, parents are independent, unless they share an arc

Advantages

1. Development of propagation algorithms
2. Number of creative applications
3. Uncertainty is handled in mathematically rigorous yet efficient and simple ways