POULIN • HUGIN
PATTERNS & PREDICTIONS

# Poulin Hugin and the Bayesian Approach

A Bayesian network (a.k.a. Bayes net, causal probalistic network, Bayesian belief network, or simply belief network) is a compact model representation for reasoning under uncertainty. A problem domain — whether to go long or to short a stock, for instance — consists of a number of entities or events. Thus, a Bayesian network consists of a qualitative part, which describes the dependence relations of the problem domain, and a quantitative part, which describes our belief about the strengths of the relations.

An observation is a piece of knowledge about the exact state of the world. However, we usually do not have complete knowledge about the state of the world — there are some things we do not know for certain. When we make observations, or in some other way obtain additional knowledge about the state of the world, we use this knowledge to update our belief about the state of the world. This is a typical example of reasoning under uncertainty. A Bayesian network can be used to compute the probability of different events or hypotheses given a number of observations.

The framework of Bayesian networks offers a compact, intuitive, and efficient graphical representation of dependence relations between entities of a problem domain. The graphical structure reflects properties of the problem domain in an intuitive way, which makes it easy for non-experts of Bayesian networks to understand and build this kind of knowledge representation. It is possible to utilize both background knowledge such as expert knowledge and knowledge stored in databases when constructing Bayesian networks. The compactness and efficiency of Bayesian network models have been exploited to develop efficient algorithms for solving queries that require complex multi-factor analysis, such as:

> "*What position should a commodity trader take on frozen concentrated orange juice futures based on weather forecast predictions regarding the upcoming crop?*", or
>
> "*What is the probability that a person applying for a loan will repay this loan given that we know the age, gender, income, and financial status?*" can be answered efficiently.

# Benefits of Bayesian Analytics

| | Bayesian | Rule Based | Neural Network | MCMC (Markov Chain Monte Carlo) |
|---|---|---|---|---|
| *Handling of Uncertainty* | ✓ | – | ✓ | ✓ |
| *Heterogeneous Modeling* | ✓ | – | – | ✓ |
| *Provable Probabilities* | ✓ | – | – | – |
| *Understanding of Assumptions* | ✓ | ✓ | – | – |
| *Analyst/Expert Modification* | ✓ | ✓ | – | – |
| *Contextual Nodes* | ✓ | ✓ | – | – |
| *Test Data Independent* | ✓ | ✓ | – | – |

## About The Features

**Handling of Uncertainty**
Often the connections between different factors — reflected by the rules defined by the user assumptions — are not absolutely certain. Bayesian-based analytics excels at handling uncertainty.

**Understanding of Assumptions**
An analyst/expert can understand what elements correlate with what other elements; something you can't accomplish using a neural network or strict Monte Carlo.

**Analyst/Expert Modification**
Probabilities can be assessed using a combination of theoretical insight, empiric studies independent of the constructed system, training and various more or less subjective estimates such as well known economic factors/rules.

**Provable Probabilities**
It can be proved that the method calculates the new probabilities correctly (e.g., based on the axioms of the classical probability theory).

**Contextual Nodes**
Neural Network Perceptrones in the hidden layers only have a meaning in the context of the functionality of the model's network. (A neural network consists of several layers of nodes. All nodes in a layer are in principle connected to all nodes in the layer just below. A node along with the in-going edges belonging to it is called a perceptrone.)

**Heterogeneous Modeling**
Multiple data types can be combined in a model.

**Test Data Independent**
While frequentist approaches (MCMC) require test data to define a pattern, the Bayesian approach can measure the data and then calculate the statistical relevance to the value observed.