

Chapter X

Overview of Bayesian Belief Network

INTRODUCTION

Statistical and probability inferences are basically dependent on two major methods of reasoning, conventional (frequentist) and Bayesian probability. Frequentists' methods are mainly based on numerous events, where Bayesian probability applies prior knowledge and subjective belief. Frequentist models of probability do not permit the introduction of prior knowledge into the calculations. This is traditionally to maintain the rigour of a scientific method and as a way to prevent the introduction of extraneous data that might skew the experimental results. However, there are times when the use of prior knowledge would be a useful contribution to the evaluation of a situation. The Bayesian approach was proposed to help us reason in situation where prior knowledge is need, and especially under highly uncertain circumstances.

This chapter provides an overview of the main principles underlying the Bayesian method and Bayesian belief networks. The ultimate goal is to provide the reader with the basic knowledge necessary for understanding the Bayesian Belief Network approach to building computational model. The chapter does not go into more technical details of probability theory and Bayesian statistics. To make it more accessible to a wide range of readers, some technical details are simplified.

Approaches to Probability Theory

Probabilistic and statistical analysis techniques and models have the longest history and strongest theoretical foundation for data analysis. Although it is not rooted

in artificial intelligence research, statistical analysis achieves data analysis and knowledge discovery objectives similar to machine learning. Popular statistical techniques, such as regression analysis, discriminant analysis, time series analysis, principal component analysis, and multi-dimensional scaling, are widely used in data mining and are often considered benchmarks for comparison with other newer machine learning techniques. Frequentist and Bayesian are two broad approaches to formal statistical inference, which are concerned with the development of methods for analyzing noisy empirical data and in particular as the attaching of measures of uncertainty to conclusions. These approaches dominate probability reasoning.

In the frequentist approach probabilities are associated only with the data or the outcomes of repeatable observations. This suggests that if an experiment is repeated many times under essentially identical conditions and if an event occurs for a certain number of outcomes, then as number of experiments grows large but on the average the ratio of the same outcomes approaches a fixed limit and this is taken as the probability of **A**.

The probability of an event therefore entails the observations of the frequency of the occurrence of a given event. In other words, the probability **P** of an uncertain event **A**, written **P (A)**, is defined by the frequency of that event based on previous observations. For example, in Saskatchewan, there can be a 50 % chance of snow in the spring. Suppose then that we are interested in the event **A**: 'a randomly selected spring season to predict Snow. In this case, the frequentist would provide us with a probability; **P (A) = 0.50**.

The frequentist approach for defining the probability of an uncertain event is reliable providing that we have been able to record accurate information about many past instances of occurrences of an event. But this gets difficult in the situation where past occurrences of an event cannot be determined. If no such historical database exists, then we have to consider a different approach. Nevertheless, the frequentist approach to probability is considered to be more objective since it can be determined independently of the observer, even though it restricts its application to repeatable phenomena.

Bayesian probability is the second approach to statistics and probability theory. This approach does not depend on repetitive trials but rather it naturally applies the laws of probability theory and formalism to reason about beliefs under conditions of uncertainty. The Bayesian approach is closer to everyday reasoning, where probability is interpreted as a degree of belief that something will happen, or that a parameter will have a given value. Bayesian approach uses prior knowledge to estimate values of model parameters. For example, what is the probability it will rain tonight given observed dark clouds in the sky?

Since this is a statement about a future event, nobody can state with any certainty whether or not it is true. Further different people may have different beliefs about the

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