The Logical Basis of Bayesian Reasoning and Its Application on Judicial Judgment

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Abstract: Bayesian inference is a law that corrects subjective judgments of related probabilities based on observed phenomena. The logical basis is that when the sample's capacity is close to the population, the probability of occurrence of events in the sample is close to the probability of occurrence of the population. The basic expression is: posterior probability = prior probability × standard similarity. Bayesian networks are applications of Bayesian inference, including directed acyclic graphs (DAGs) and conditional probability tables (CPTs) between nodes. Using the Bayesian programming tool to construct the Bayesian network, the ECHO model is used to analyze the node structure of the proposition in the first trial of von Blo, and the jury can be simulated by the insertion of the probability value in the judgment of the jury in the first instance, but find and set The difficulty of all conditional probabilities limits the effectiveness of its display of causal structures.

1. Introduction

The British mathematician Thomas Bayes (about 1701-1761) used inductive reasoning for the basic theory of probability theory and created Bayesian statistical theory, namely Bayesian reasoning. After the continuous improvement of scholars in later generations, a scientific methodology system has gradually formed, "applied to many fields and developed many branches." [1] Bayesian reasoning needs to reason about the estimates and hypotheses to be made based on the sample information observed by the observer and the relevant experience of the inferencer. This is a classic statistical inductive reasoning. Bayesian reasoning has been widely used in judicial decisions.

2. The logical basis of Bayesian inference

Bayesian rule

The Bayesian rule is a standard method for correcting the subjective judgment (prior probability or pretest probability) of a correlation probability by a phenomenon created by Bayesian. The basis of its argument is that when the sample's capacity is close to the population, the probability of an event occurring in the sample is close to the probability of the population occurring. The conditional probability represents the probability of occurrence of event A under the condition that another event B has occurred.

The probability that event A occurs under event B is different from the probability that event B occurs under event A. The basic expression is -

In general, if event B can be observed, the probability that event A is true is:

Probability of A independent of B × When A is true B Probability of B / B is independent of A, ie: $P(A|B)=P(A)\times P(B|A)/P(B)$

Where P(A), the probability that A is independent of B, is called prior probability, P(B|A)/P(B) is called standard similarity, and P(A|B) is also called posterior probability. Therefore, the Bayesian rule can be expressed as:

Posterior probability = prior probability × standard similarity

E.g:

Event A and Event B, A is a girl on campus, and B is a student wearing a pair of pants on the

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campus. To calculate is P(A|B).

P (A) sees the probability of girls is 40%,

P(A') sees that the probability of not being a girl (ie seeing a boy) is 60%.

P(B|A) is the probability that girls wear pants, which is 50%.

P(B|A') is the probability that a boy wears a trousers and is 100%

P(B) is the probability that students wear pants, ie

P(B) = P(B|A)P(A) + P(B|A')P(A'), which is 0.5 × 0.4 + 1 × 0.6 = 0.8.

According to Bayes' theorem, the posterior probability P(A|B) is calculated.

P(A|B)=P(B|A)*P(A)/P(B)=0.25. It can be seen that the posterior probability is actually the conditional probability.

For example, in the judicial adjudication: Simpson's wife's case was sensational in 1994, but several major mistakes by the police led to the acquittal of Simpson. The case became the biggest suspect in the history of justice in the United States. In the case, his defense lawyer said that there is data showing that male spouses abuse women and eventually kill them less than one-thousandth, so Simpson's abuse and killing of his wife are not necessarily linked. In fact, this data does not support the conclusion. According to Bayes' rule, we are required to amend the newly emerging information. The new message is that Simpson's wife has indeed died of murder. So the probability of Simpson as a illicide, whether it is a murderer, will be much higher than one thousandth.

3. The application of Bayesian reasoning - Bayesian network

The Bayesian network (BN) proposed by Judea Peal in 1988 is also called the reliability network. It is a network based on probability and uncertainty. It is the most effective theoretical model in the field of uncertain knowledge representation and reasoning. One. Because it combines theories and techniques such as probability theory and graph theory artificial intelligence, it proposes tools for problem modeling and analysis to solve the problem of uncertainty and incompleteness. It is very difficult to solve the faults caused by the uncertainty and correlation of complex equipment. The big advantage has been widely used in many fields such as artificial intelligence, automatic control, and information retrieval.

Bayesian network visualizes multivariate knowledge, implies the causal relationship between network node variables, expresses the correlation between various information elements with conditional probability, and diagnoses faults under limited incomplete and uncertain information conditions. Various information related to maintenance decision-making is incorporated into the network, processed in a unified manner by nodes, and effectively integrated and expressed according to the correlation of information, thereby reasoning and learning.

The Bayesian network consists of two parts: 1) Bayesian network structure diagram, which is a directed acyclic graph (DAG). [2] Each node in the figure represents the corresponding variable, the connected part between nodes represents the conditional independent semantics of the Bayesian network; 2) The conditional probability table (CPT) between the node and the node, that is, a series of probability values, if The Bayesian network provides sufficient conditional probability values, which are computationally inferior. E.g:

Hypothesis: Proposition S: A patient is a smoker

Proposition C: The patient is a coal mine worker

Proposition L: The patient has lung cancer

Proposition E: The patient has emphysema

Proposition S has a causal effect on proposition L and proposition E. Proposition C also has a causal effect on E. The relationship between propositions can be portrayed as a corresponding causal network. In a Bayesian network, the join point expresses a direct causal relationship. It shows two elements of the Bayesian network: a directed acyclic graph (DAG) and a probability table describing the vertices, each vertex corresponding to a random variable. The network diagram expresses a set of conditional independent attributes: each variable is probabilistically independent of its non-inherited nodes in the graph given the state of the parent node.

Legal trials can provide a broad and detailed analysis using probability theory. Richard A. Posner

believes that “evaluating probability is a useful and rational way of dealing with uncertainty; when new information is injected, people should update the probability of assessment, and new information for people ultimately The impact of decision-making depends on people's chances of pre-test."[3] 102 Bayesian network can provide rational support for legal reasoning, you can try to pass the Bayesian network to the jury of the Claus von Blow case Reasoning provides a reasonable way to interpret.

A Bayesian network is a network of nodes. The arrows on these nodes represent the probability dependencies: If A→B, then the probability of B depends partly on the probability of A. In addition, the arrow can also be interpreted as a causal relationship: If A→B, then A has a causal effect on B.

Sagad built a Bayesian network using Java Bayes programming tools. [4] This network uses the ECHO model to analyze the node structure of propositions in the first trial of von Blow. The connection that constructs the causal network is unidirectional, and each node has n arrows to enter, and 2n+1 conditional probabilities are specified. The jury, which can be simulated by inserting a probability value, is judged in the first trial of the von Blow case. The Bayesian network calculates the posterior probability of each node using the provided conditional probability and some node information that is marked as true. The probability of a simulated Claus-injection is greater than .5, and Sonny's own-injection probability is less than .5. Using the Bayesian network, the first-instance jury found von Blow guilty.

It should be pointed out that Sagad et al. are skeptical about the Bayesian reasoning of the jurors in the trial. On the one hand, the interpretation relationship based on causality needs to specify the conditional probability. Otherwise, the Bayesian classification algorithm and similar programs will have no effect. On the other hand, it is difficult for the Bayesian network to find out all the conditional probabilities that the analysis requires. The reasoning simulation of the von Blow first trial requires 96 conditional probabilities, and the use of Java Bayes applications and other more complex cases may require more conditional probabilities. Therefore, the really important role of the Bayesian network in judicial adjudication is to demonstrate an effective causal structure.

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