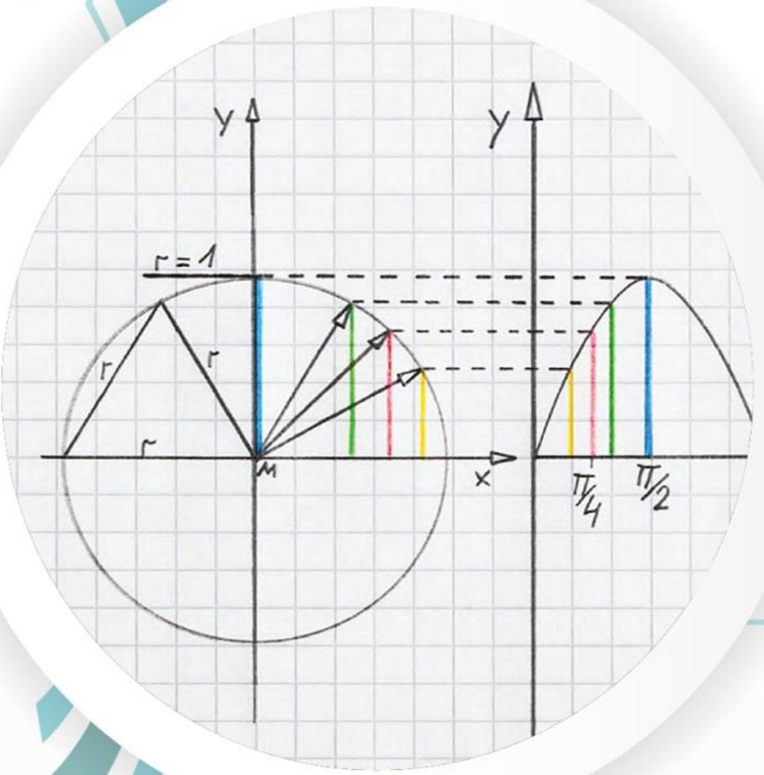
ISSN : 1687-6156 (ONLINE)

INTERNATIONAL JOURNAL OF

ENGINEERING MATHEMATICS: THEORY AND APPLICATION



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PRINCIPLES OF OPERATION AND EFFICIENCY OF BAYESIAN NETWORKS IN LOGIC SCHEMES USED IN ARTIFICIAL INTELLIGENCE

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Abstract. This article analyzes the logic schemes used in artificial intelligence systems and the principles of Bayesian networks. Bayesian networks, based on probability theory, allow for decision-making in complex systems and analysis of data under uncertainty. The article discusses the effectiveness of networks, their advantages in the modeling process, and areas of application. Information is also provided about the specific aspects of Bayesian networks and methods for optimizing them.

Keywords. Mathematics, Mathematical Logic, mathematical reasoning, artificial intelligence, conditional probability, full probability, Bayesian theorem, Bayesian formula, confidence level, Bayesian network.

Introduction. The use of Bayesian networks in the economic, social and technical-technological development of our country, in the logical schemes used in artificial intelligence, is of great importance in fulfilling the tasks specified in the resolutions of the President of the Republic of Uzbekistan Sh. Mirziyoyev: No. PQ-3775 dated June 5, 2018 “On additional measures to improve the quality of education in higher educational institutions and ensure their active participation in the comprehensive reforms being implemented in the country”, No. PQ-4708 dated May 7, 2020 “On measures to improve the quality of education in the field of mathematics and develop scientific research” and No. PQ-4996 dated February 17, 2021 “On measures to create conditions for the accelerated introduction of artificial intelligence technologies”. This reflects the relevance of the chosen topic.

Bayesian networks provide a framework that allows artificial intelligence systems to learn, reason, and make intelligent decisions. Bayesian networks are learned through mathematical logical reasoning.

Mathematics serves as the basis for artificial intelligence algorithms and models, which allow machines to process, analyze, and interpret large amounts of data.

Artificial intelligence is the development and use of intelligent machines, drawing on many fields, including psychology, mathematics, biology, and engineering, to create computers that can think, react, and change their behavior based on new information, like humans.

The importance of mathematics in artificial intelligence systems - algorithms use mathematical models and calculations used in machine learning, so artificial intelligence systems can automatically improve over time based on feedback from the environment.

Artificial intelligence (AI) is actively used today in various fields of science, technology, and everyday life. The effectiveness of AI systems depends on their decision-making ability, which is formed through mathematical logic schemes. Mathematical logic schemes play an important role in various models of artificial intelligence, and their correct operation ensures the reliability and efficiency of AI systems.

Currently, artificial intelligence (AI) technologies are widely used in various fields. The decision-making process in AI systems is carried out on the basis of mathematical logic schemes and probability models. In this article, we aim to consider Bayesian networks (BN) and their application in artificial intelligence, principles of operation and effectiveness.

Literature analysis and methods.

Mathematical logic is the laws, methods, and formulas (forms) of reasoning, and its founder is considered to be the ancient Greek thinker Aristotle (384-322 before christ).

A mathematical statement is a statement that can only accept one of two possible outcomes: “a certain event” or “an impossible (impossible) event”.

A logic diagram is a set of formal rules, logical expressions, and algorithms used to solve a specific problem or make a decision. It is used to control the processes of processing, analyzing, and drawing conclusions from information.

Bayesian networks are an important component of artificial intelligence systems based on probability theory and graphical models. They are used to manage uncertainty, analyze, and make decisions in complex systems.

Bayesian networks are mainly composed of the following components:

- ✓ Nodes - represent variables;
- ✓ Directed edges - represent relationships between variables;
- ✓ Probability distribution - a set of conditional probabilities for each node.

Bayesian networks use special algorithms to correlate statistical data and predict expected outcomes.

There are several scientists in the field of artificial intelligence who have conducted scientific research and written works on Bayesian networks.

Thomas Bayes is the author of Bayes' theorem, and his work forms the theoretical basis of Bayesian networks.

Judea Pearl is a leading researcher in the field of Bayesian networks and probabilistic artificial intelligence. Her book “Probabilistic Reasoning in Intelligent Systems” is one of the main sources on Bayesian networks.

George Boole - Known for his work on expressing logical thinking through mathematical equations. His work had a major impact on the development of artificial intelligence and logic circuits.

Kevin Murphy is a leading researcher in probabilistic graphical models and Bayesian networks. His book "Machine Learning: A Probabilistic Perspective" is an important reference in this field.

Steffen L. Lauritzen - A leading expert on probability networks and statistical logic schemes.

Michael I. Jordan - A renowned scientist in the field of machine learning and statistical analysis, who has also done important work on Bayesian networks.

The work of these scientists is important in understanding the principles and effectiveness of Bayesian networks and logic circuits in artificial intelligence.

Results.

The principles of Bayesian networks include the following steps:

- ✓ Model creation - identifying variables and determining their relationships;
- ✓ Determining probability distributions - calculating conditional probabilities for each variable;
- ✓ Analysis and calculation - predicting outcomes based on known data;
- ✓ Updating - recalculating probabilities based on Bayes' rule when new data is entered.

These principles help to optimize the process of working with data in artificial intelligence systems. Bayesian networks are effective for the following reasons:

- ✓ Working under uncertainty - allows you to make optimal decisions even when complete information is not available;
- ✓ Flexibility - the model can be quickly updated when new data is entered;
- ✓ Analysis of complex systems - allows you to model systems that include many interdependent factors;
- ✓ Efficiency and accuracy - works faster and has higher accuracy than other statistical models.

Bayesian networks are widely used in robotics, cybersecurity, financial analysis, and medicine. For example, in the medical field, a Bayesian network to diagnose "Pneumonia" might look like this:

1) Nodes - weather, chills, fever, cough, pneumonia.

2) Connections - chills → fever → cough → pneumonia.

3) Probability tables - for example, if the probability of chills is 0.3, the probability of fever can be 0.7.

Based on the given data, the probabilities are recalculated. Decisions are made using inference algorithms.

Thomas Bayes (1702-1761) - British mathematician (clergyman), fellow of the Royal Society of London (1742).

Bayes' theorem states that the probability of any event is equal to the frequency of its occurrence. According to the theorem, we get the frequency by measurements.

We divide the number of known events by the total number of measurements - this is the probability of the event.

The probability of event A occurring given that event B occurs is called the conditional probability of event A occurring given that event B occurs and is denoted by $P_B(A)$ or $P(A/B)$.

Theorem. The probability of the product of events A and B is equal to the product of the probability of one of the events and the conditional probability of the second event given the occurrence of the first event:

$$P(A \cdot B) = P(A) \cdot P_A(B) = P(B) \cdot P_B(A) .$$

For n events $(A_1, A_2, A_3, \dots, A_n)$:

$$P(A_1 \cdot A_2 \cdot A_3 \cdot \dots \cdot A_n) = P(A_1) \cdot P_{A_1}(A_2) \cdot P_{A_1 A_2}(A_3) \cdot \dots \cdot P_{A_1 A_2 \dots A_{n-1}}(A_n) .$$

Let the disjoint events $B_1, B_2, B_3, \dots, B_n$ form a complete group. Let event A occur when these events occur. Here $B_1, B_2, B_3, \dots, B_n$ are called hypotheses. Then

$$P(A) = P(B_1) \cdot P_{B_1}(A) + P(B_2) \cdot P_{B_2}(A) + \dots + P(B_n) \cdot P_{B_n}(A)$$

or

$$P(A) = \sum_{i=1}^{n} P(B_i) \cdot P_{B_i}(A)$$

it will be. This formula is called the complete probability formula.

Let $B_1, B_2, B_3, \dots, B_n$ be hypotheses, and their probabilities $P(B_1), P(B_2), P(B_3), \dots, P(B_n)$ be given. Let an experiment be conducted, as a result of which event A occurs, and let the conditional probabilities $P_{B_1}(A), P_{B_2}(A), \dots, P_{B_n}(A)$ be known. Then

$$P_A(B_i) = \frac{P(A \cdot B_i)}{P(A)} = \frac{P(B_i) \cdot P_{B_i}(A)}{\sum_{i=1}^{n} P(B_i) \cdot P_{B_i}(A)}$$

it will be. This formula is called Bayes' formula.

Bayes' formula is a mathematical equation used in probability and statistics to calculate conditional probability. In other words, it is used to calculate the probability of an event based on its association with another event. This formula is also known as Bayes' theorem, Bayes' law, or Bayes' rule.

There are several different ways to write the formula for Bayes' theorem. In particular:

$$P(A - B) = P(B - A) \cdot P(A)/P(B)$$

or

$$P(A \backslash B) = \frac{P(A \cap B)}{P(B)} = \frac{P(A) \cdot P(B \backslash A)}{P(B)}$$

where A and B are two events and $P(B) \neq 0$.

$P(A - B)$ or $P(A \backslash B)$ is the conditional probability of event A occurring, given that B is true.

$P(B - A)$ or $P(B \backslash A)$ is the conditional probability of event B occurring given that A is true.

$P(A)$ and $P(B)$ are the probabilities (marginal probabilities) of A and B occurring independently of each other.

Bayesian networks are based on Bayes' theorem, a fundamental concept in probability theory that allows probabilities to be updated based on new evidence. Bayesian networks use this theorem to model probability relationships between variables, making them ideal for handling uncertainty and incomplete data.

Example: Using mathematical reasoning, we can form a network according to the following formula (Figure 1):

$$P(A \backslash B) \cdot P(B) = P(A \cap B) = P(B \backslash A) \cdot P(A)$$

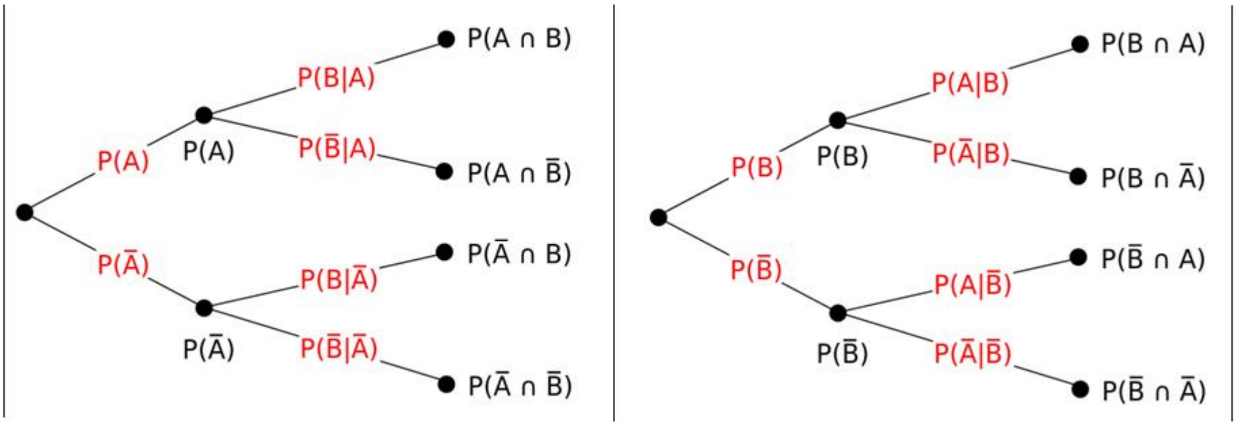

Figure 1.

Bayes' theorem relates (measures) the "confidence level" in a proposition before and after considering the evidence.

Discussion. Bayesian networks are a type of probabilistic graphical model that has gained considerable popularity in the fields of artificial intelligence and machine learning. They are used to model and represent the relationships between different variables in a system, and to graphically capture their dependencies and uncertainties.

One of the main strengths of Bayesian networks is their ability to be applied to a wide range of tasks, such as prediction, classification, decision-making, and diagnostics. They are particularly useful in scenarios where explanation and interpretation are important, as they provide a transparent and intuitive way to model complex systems.

The structure of a Bayesian network graphically represents the relationship between variables, while the parameters represent the probability distribution of the variables given their underlying variables.

Conclusion. In summary, one of the main advantages of Bayesian networks is their ability to explain their predictions and their causes. Bayesian networks offer an attractive solution for building transparent and interpretable artificial intelligence models. By providing a formal and probabilistic way to represent and reason about uncertain knowledge, Bayesian networks bridge the gap between sophisticated machine learning models and human understanding, making them a valuable asset in the field of artificial intelligence.

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