

# APPLICATION OF MATHEMATICS TO INFORMATION TECHNOLOGIES

Akbar Adizovich Adizov

Tashkent State University of Economics Associate Professor of the  
Department of Information Systems and Technologies

## Abstract

It is known that mathematical modeling plays an important role in many fields - from physics and engineering to biology and economics. This article examines information technologies used to create, visualize, and analyze mathematical models. Various types of technologies, including graphical interfaces, computational algorithm libraries, big data and machine learning technologies, as well as interactive web applications, are described. The article also provides practical examples of using information technology in various industries where mathematical modeling is used.

**Keywords:** Information technology, computer algebra systems, computational platforms, graphical interfaces, computational algorithm libraries, big data and machine learning, interactive web applications.

## Introduction

Information technology is a system of methods, techniques and tools designed to obtain, store, process, transmit and use information, as well as to automate work with data and improve the efficiency of business process management. These technologies include computer programs, databases, network technologies, information systems and other components necessary to ensure high quality information processing in organizations of various types and areas of activity [1]. There are many different technologies that are used in mathematical modeling. Let's consider some of them.

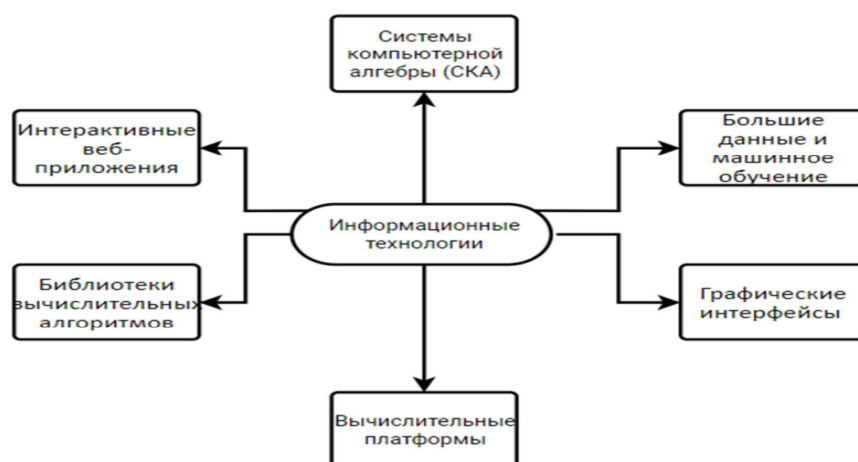


Fig. 1. Information technology

Computer algebra systems (CAS) allow you to automate the process of working with mathematical expressions, simplifying the solution of complex mathematical problems. Examples of CAS are Wolfram Mathematica, Maple and Matlab [5]. CAS are effectively used in algebra, geometry, analysis and other areas of mathematics. For example, with the help of CAS, you can solve systems of equations, find derivatives and integrals, find analytical formulas for functions, etc. In the field of mathematical modeling, CAS are used to create analytical models, for symbolic and numerical solution of differential equations and for optimization of the modeling process. Computing platforms allow you to create and run mathematical models on clusters or virtual machines. Examples of computing platforms are Amazon Web Services (AWS), Microsoft Azure and Google Cloud Platform. Computing platforms provide high performance and scalability when solving mathematical modeling problems [3]. For example, using AWS allows you to quickly create and scale computing clusters for solving mathematical modeling problems. Virtual machines allow you to run programs on different operating systems, which is especially useful when developing cross-platform software.

Graphical interfaces facilitate the process of visualizing and analyzing the results of mathematical models. Examples of graphical interfaces are Paraview, VisIt, and Tecplot. Paraview can be used to visualize 3D graphs and analyze the results of mathematical models, for example, when modeling climate change forecasts, while VisIt allows you to create complex visualizations, including animations and visualization of streaming data.

Libraries of computational algorithms provide implementations of various mathematical methods and algorithms for solving mathematical modeling problems [4]. For example, BLAS and LAPACK contain implementations of linear algebra algorithms, while OpenMPI and OpenCL allow you to create parallel and distributed computing, effectively solve linear algebra problems, for example, when modeling physical processes in materials.

Big data and machine learning allow you to create and process large amounts of data and apply machine learning methods to build mathematical models [3]. Big data and machine learning are used to create predictive models and analyze large amounts of data. For example, Spark allows you to process and analyze large amounts of data, and TensorFlow is used to build neural networks and other machine learning models. Machine learning and big data analysis can be used to build predictive models, for example, when modeling financial markets or

healthcare processes, in tasks of predicting consumer and market behavior, developing and using software packages in the field of economics and ecology. Machine learning and big data analysis are also great for solving optimization problems and finding optimal solutions in various areas, for example, in production management, logistics, etc.

Interactive web applications are applications that can be run in a web browser and interacted with through an interface built on web technologies such as HTML, CSS and JavaScript, they allow the creation of interactive applications for visualization and analysis of mathematical models accessible through a web browser. Examples of technologies are D3.js, Plotly and Bokeh.

All of these technologies have their advantages and disadvantages, and the choice of a particular technology depends on the task and the requirements for the performance and accuracy of the solution. Here are practical examples of the implementation of information technologies in various industries where mathematical modeling is used. In medicine: the use of computer technologies to create three-dimensional models of organs, tissues and body systems, for example, for diagnosing diseases and planning operations.

In manufacturing: the use of information technologies to optimize production processes, inventory management and logistics, for example, to increase efficiency and reduce costs.



Organization of the educational process using modern communication and information technologies allows us to solve the following problems:

- providing students with the opportunity to study directly at their place of residence or temporary stay in the event that it is temporarily impossible to attend an educational institution;

- providing conditions for learning taking into account the characteristics of psychophysical development, individual capabilities and needs of students.

The use of modern communication and information technology teaching methods is implemented in the following stages: preparatory, educational, final.

The preparatory stage is implemented in four steps:

- analysis of the possibility of organizing the educational process using distance learning technologies (the task is to establish students' capabilities to use communication and information technologies, providing assistance in installing the appropriate tools);
- drawing up a class curriculum - establishing lesson topics in which the use of communication technologies is appropriate;
- designing lesson scenarios;

obtaining passwords for students to access communication resources. The features of the educational stage are:

- reflection of the structure of educational mathematical activity;
  - interaction between the network teacher and students;
  - ensuring that students master the content of the subject in accordance with general and individualized goals;
  - monitoring and diagnostics in order to correct the further trajectory of learning.
- The final stage is focused on monitoring the achieved level of mathematical knowledge, skills, and abilities.

The use of distance learning technologies allows:

- □ students to acquire deep and solid knowledge through information and communication technologies,
- □ develop students' cognitive abilities to independently acquire, expand and deepen knowledge, and apply it in practice.

Let's consider the most popular platforms of modern communication and information technologies for learning.

### Real-World Applications of Mathematics in Computer Science

It may seem like computers only use ones and zeros, but mathematics is actually the powerful language behind them. Mathematics drives everything in computer science, from the circuits in our devices to the algorithms in our favorite apps.

Mathematics is closely related to computer science. It provides the theoretical foundation and practical tools to solve complex problems, develop algorithms, and analyze data. Here are some key areas where mathematics is applied in computer science:

## Applications of Mathematics in Computer Science

Computer science is based on mathematics, which influences many things that determine how we use technology. That is why mathematics plays a big role in computer science:

Various applications of mathematics in computer science include:

- Algorithms
- Data structures
- Cryptography
- Graphics
- Artificial intelligence (AI)
- Data compression

Let's learn about the same in more detail.

### Algorithms

An algorithm is like the basic building block of any computer program. It is a step-by-step method that tells the computer how to solve a problem. To create fast and efficient software, it is important to design efficient algorithms. This is where mathematics takes the lead, using concepts from graph theory, linear algebra, and calculus.

For example, sorting algorithms use ideas from complexity theory and combinatorics to organize data efficiently. Imagine searching through a large library catalog. A good sorting algorithm based on mathematics can help you find the book you need quickly.

### Data Structures

Data structures are special ways of storing and organizing data in a computer's memory. Choosing the right data structure can have a big impact on how well a program performs. People often use mathematical concepts such as trees, graphs, and hash tables when designing efficient data structures.

- For example, searching algorithms rely heavily on how well data structures are organized to find information quickly. Think of it like a phone book: a well-organized hash table (based on mathematical ideas) will help you quickly find a specific number.





## Cryptography

In today's digital world, it's important to communicate securely. That's where cryptography comes in — it uses mathematics to keep data secure and private. Many cryptography methods are based on complex mathematical problems, such as elliptic curve cryptography and integer factorization.

For example, the RSA encryption method is based on the problem of factoring large prime numbers, making it a common choice for secure communication. Suppose you're sending a personal email. Cryptography, which uses mathematics, scrambles the message so that only people with the right key can read it.

## Graphics

Computer graphics create the beautiful images and animations we see on our screens. Knowledge of mathematics, especially geometry, algebra, and calculus, is crucial to creating realistic and appealing images. These mathematical methods are used for, among other things, 3D modeling, image editing, and lighting simulation.

- Consider a high-definition video game. They use complex mathematical calculations to create realistic movement and lighting, and to create a convincing impression.

## Artificial Intelligence (AI)

The world is changing rapidly thanks to AI, and mathematics plays a big role in this change. Artificial intelligence (AI) algorithms are becoming increasingly complex and are used for tasks like machine learning, robotics, and understanding human language. Many AI techniques use mathematical concepts from fields like probability theory, calculus, and linear algebra.

- For example, machine learning algorithms use linear algebra to perform tasks like regression and classification. Consider an email spam filter. It uses math-based machine learning to scan incoming emails and accurately detect spam.

## Data Compression

As more and more data is created, it is important to have reliable ways to compress data. This is where information theory comes in. Mathematicians can create compression algorithms that save storage space and speed up data sending by learning patterns in the data.

- Consider sending a large video file. Compression using mathematics can make a file much smaller without losing quality, making it easier to transfer and store.

Thus, information technology is an integral part of the modern world and will continue to develop and find new areas of application in mathematical modeling and other areas.

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