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MATHEMATICS AS A PRAEBENDA AND FOREFRONT OF COMPUTER SCIENCES

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ABSTRACT

Mathematics is the foundation stone for many sciences and engineering disciplines. Various problems which arise in computer science can be easily analysed and solved using different mathematical models and methods. Discrete mathematics, which involves discrete mathematical structures like graphs, algorithm, computational geometry, quantum computation, algebra and computational number theory, is the basis of algorithms used in computer science, software engineering and information systems. 'Logic' used in computer systems, finds its root in mathematical principles. Core concepts of computer science like Cryptography , software development , computer vision , image analysis, graphics and animations etc. involves various theories of mathematics viz. set theory , matrices, graph theory , Boolean Algebra , probability and numerical analysis . Mathematics also plays an effective role in the development of mathematical morphology and digital technology. In fact, mathematics is a natural complementary discipline for learning, understanding and appreciating many fundamental concepts of computer science.

I. EXORDIUM

Mathematics is the cradle of all creations as mathematics has been contributing in each and every field or sector in today's time, hence its importance and utility has also been identified in computer sciences as well. Especially mentioning, Babbage, Hilbert, Boole, Von Neumann, Turing; computer science grew out of mathematics. It is also one of the most crucial elements in computer sciences. Algebra, the basic mathematics, is the most frequently used by a successful computer scientist.

Mathematical tools like logical, comparison, arithmetic, assignment and conditional operators from the basis for all programming languages.

Applications of mathematics in different concepts of computer science:

- The concepts of discrete mathematics form a basis for representation of data, its organisation and networks etc.
- Different mathematical tools are used in the development of digital technology.
- Mathematical concepts of coding theory are applied in Cryptography, setting passwords, data transmission and correcting codes etc.
- Mathematical morphology, which involves image analysis, uses the concepts of trigonometry, lattices and set theory.

II. DISCRETE MATHEMATICS AND COMPUTER SCIENCE

Discrete mathematics, known as mathematical language of computer science, deals with objects that can assume only distinct, separate values. Combinatorics deals with the study of how discrete objects combine with each other and the probabilities of various outcomes. The areas of discrete mathematics, which are relevant to computing and used in theoretical computer science. Mathematical logic is the study of principles of valid reasoning and inference, consistency and soundness. Logical formulae are discrete structures which form tress or directed acyclic graph structure. The truth values of logical formulae usually form a finite set.

The theory of graphs and networks is used in computer science to represent networks of communication, data organisation, and computational devices and flow of computation etc.

Boolean algebra is used in logic gates and programming relational algebra is used in databases. Discrete semi-groups and monoids are used in the theory of formal languages. These are very useful not only for creating logical solution, but also very useful in programming.

Computational geometry forms the basis for algorithms to geometrical problems.

Trees are used to represent data that has some hierarchical relationship among the data elements.

Graph theoretical concepts are also used in traveling salesman problem, in shortest spanning trees, in weighted graph, modelling transport networks etc.

The understanding of set theory, probability and combinations helps in analysing algorithms. One can successfully identity the parameters and limitations of one's algorithms and can have the ability to realize how complex a problem / solution is.

III. MATHEMATICS AND DIGITAL TECHNOLOGY

Digital technologies refer to a wide range of devices which combines the traditional elements of hardware (processing, memory, input, display, communication, peripherals) and software (operating system and application programs) to perform a wide range to tasks. They include: technical applications, consumer applications, communications applications and educational applications.

Mathematical work is based on important practical issues of the society. The social, economic, ecological and technological data requires strong mathematical tools, so that these data can help in tackling the society challenges. The new applications of the graph theory to networks are helping in understanding how patterns can be detected, understood and managed.

These are numerous mathematical techniques which are used to design various models and also to implement them. For example, signals and systems thrive calculus and trigonometry. It also involves matrices, and linear modelling.

Also the whole system involved in the use of mobile phones (Modelling the Channel-Curve fitting, GSM cell division strategies –differential equations, routing algorithms-linear programming) is dependent on tremendous use of mathematics.

IV. MATHEMATICS AND CRYPTOGRAPHY

Cryptography involves securing information through (Cryptographic system is a mathematical system for encrypting or transforming information, so that it is un intelligible and therefore useless to those who are not meant to have access to it. The encryption system generally begins with the conversion of the plaintext, or unenciphered message into a string of numbers by means of a digital alphabet.) encryption algorithms. It builds from the field of pure mathematics known as number theory, which deals with integers. Tools like factorisation and computing logarithms are used. Abstract mathematics plays an important role in the development of cryptography. Game theory has been used in constructing protocols in rational setting.

Coding theory and many combinatorial designs like BIBD's, Orthogonal arrays are used in construction of universal hash function families and pseudorandom number generators. Algebraic geometry has been used in elliptic curve cryptography. Group theory has been used to construct cryptographic primitives secure against quantum attack.

The hard-core predicates which are of great use in theoretical cryptography can be constructed and proved using discrete Fourier analysis. In some cryptosystems, additive combinatorics are used in complexity theory.

V. MATHEMATICAL MORPHOLOGY

Mathematical morphology deals with the mathematical theory of describing shapes using set theory, topology, stochastic geometry, lattice theory, non-linear differential equations etc. It is applied to process digital images and other forms of spatial structures as graphs, surface meshes, data clouds etc.

The three basic concepts of set theory namely union, intersection and complement are used in morphological operators like structuring elements, erosion, dilation, opening and closing etc. The main assumption is that the object space is complete lattice and the transformations of interest are invariant under a given abelian group of automorphisms on that lattice. It reveals that the basic operations called dilation and erosion are adjoints of each other in a very specific lattice sense and can be completely characterized if the automorphism group is assumed to be transitive on a sup-generating subset of the complete lattice. Important information about the geometrical construction of an image can be obtained by matching it with smaller patterns at various locations in the image. This can be done successfully with the knowledge of angles. (Trigonometry)

VI. CONCLUSION

The basics of computers; binary numbers have base in mathematics. As discussed above, discrete mathematics is used for the development of digital computers. Matrix Algebra, 3-D geometry, graph theory etc. are also very useful in many computer applications. Computer games and animations use graphics. Thus mathematics has influenced the computer science to the greatest extent. Undoubtedly, mathematics is an inherent part of computer science. All computer science applications require mathematics to some degree. To tackle the most challenging programs, mathematics will be of huge aid.

A well-known computer scientist, Hoare had made the following assertions:

- Computer programs are mathematical expressions.
- A programming language is a mathematical theory.
- Programming is a mathematical activity.

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