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Application of Mathematics in Computer Science

Dr. Dhiraj Yadav
Department of Mathematics
Government College for Women, Rewari, Haryana, India
dhiraj1339@gmail.com

Abstract: *No one escape the learning of mathematics in one way or other, ranging from our kitchen to our journey from earth to Moon or Mars. Mathematics persists everywhere around us. It can be perceived in our garden or park from symmetry of leaves, flowers, fruits etc. and by so many examples of Geometry and symmetry can be seen in nature. God used mathematics in creation of the universe in one form or the other. Likewise, Mathematics is the queen of all sciences. Scientists and researchers can not perfectly accomplish their work without including mathematics. Mathematics is the foundation of Computer Science. If one is eager to learn any arena of Computer Science, first he/she has to imbibe a love of Mathematics that will be supportive for progressive learning of the said subject. Mathematics is friendly for analytical skills needed in Computer Science. Concepts of binary number system, Boolean algebra, Calculus, Discrete mathematics, linear algebra, number theory, and graph theory are the most applicable to the subject of computer science with the emergence of new concepts like machine learning, artificial intelligence, virtual reality and augmented reality.*

Keywords: Binary Number System, Discrete Mathematics, Calculus, Computer Science, Number Theory, Graph Theory, Machine Learning, Artificial Intelligence.

I. INTRODUCTION

Everyone knows that MATHEMATICS is the distinguished star of a Galaxy of Sciences in this universe. Interface with the outside world is must for generation of mathematical acumen and prowess. Mathematics is an important foundation for many areas of science and engineering. It is always difficult to constitute precise boundary lines as a tool of compartmentalization among disciplines (compare, for example - the subject of physical chemistry and chemical physics, etc.).Many computers scientists have been doing mathematics, but many more mathematicians have been studying computer science in disguise .In the modern era, variegated sciences are interdependant. The different social sciences cannot have their existence independent of others. These are interrelated; one subject is complementary component of another. Various subjects of sciences have much in common but are distinct from each other. New education policy, July 2020 has also supported this interdisciplinary approach.

Sometimes it becomes a matter of discussion about the significance of Mathematics in Computer Science. Some scholars argue that it contributes only little value in Computer Science while others (mostly in the majority!) say that it is the foundation for Computer Science. *According to the University of Oxford:*

Mathematics is a fundamental intellectual tool in computing, but computing is also increasingly used as a key component in mathematical problem-solving.

If we focus on the study of algorithm, isn't this merely a branch of MATHEMATICS? After all, algorithm was primarily evolved by a mathematician, Al-Khwarizmi, before the days of computer science, He evolved the methods for solving problems which used step by step instructions. An algorithm includes a finite number of steps each of which may have a number of operations.

Computer scientists use mathematics in their professional lives in one way or other. Mathematics delivers the theoretical basis for many branches of computer science, and important analytic tools for others. Computer scientists

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thus apply specific mathematical topics to specific computing problems. Mathematics facilitates the Analytical Skills needed for problem-solving and data analyzation. Hence by judiciously perceiving, it is found that computer science initially emerged as a branch of mathematics and then afterword existed as a separate and independent subject

II. Objective of the Study

The objective of this study is to analyze the application of Mathematics in Computer science in present scenario of multidisciplinary approach by careful study of literature of mathematics as well as computer science.

III. Significance of Mathematics

Let us through light on the significance of various concepts of different branches of Mathematics in the arena of computer science.

3.1 Binary Math

It is the core of computer operation and among the utmost important type of math used in computer science. To symbolize every number within the computer, binary is used. Binary is a number system that includes only two digits 0 and 1. All information executed by a computer is in the form of a sequence of 0s and 1s. Therefore, all data which we require to process by a computer needs to be converted into binary. Computers use binary the digits to store data. The circuits in a processor of computer are structured of billions of transistors. The digits 1 and 0 used in binary exhibit as on and off position of a transistor. Standard arithmetic is applied in various functions of computer programming. Arithmetic operations like addition, subtraction, multiplication, and division are used in most of the written programs,

3.2 Discrete Mathematics

It is a branch of mathematics involving discrete elements that uses algebra and arithmetic. Discrete Mathematics is the mathematical language of Computer Science and a learner has to be well versed in this to work in many fields related to computer science. Concepts and notations from said branch of mathematics are supportive to study and describe objects and problems in different area of computer science like as computer architecture, algorithms, programming languages, cryptography, automated theorem proving, and software development, machine learning, operating systems, computer security, and networks.

3.3 Boolean Algebra

It is used to analyze and simplify the digital (logic) circuits. It uses only the binary numbers i.e. 0 and 1. It is also named as Binary Algebra or logical Algebra. The concept of Boolean algebra was first introduced by George Boole in 1854 in his book, “The Mathematical Analysis of Logic”, and further extended in his book, An Investigation of the Laws of Thought. The significance of Boolean algebra exists in the theory of probability, geometry of sets, and information theory. Furthermore, it exists as the basis for the design of circuits used in electronic digital computers, computer programming, and mathematical logic, and is also used in other areas of mathematics such as set theory and statistics.

A Boolean function is an algebraic expression formed with binary variables, the logic operation, parenthesis, and equal sign. A Boolean function can be converted from an algebraic expression into a logic diagram possessed of AND, OR, NOT (inverter) gates.

3.4 Boolean Addition

The basic rules of Boolean addition are as follows

$0 + 0 = 0$,
$0 + 1 = 1$,
$1 + 0 = 1$,
$1 + 1 = 1$

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Boolean addition is same as logical OR addition.

3.5 Boolean Multiplication

The rules of Boolean multiplication method are as follows:-

0.0=0
0.1=0
1.0=0
1.1=1

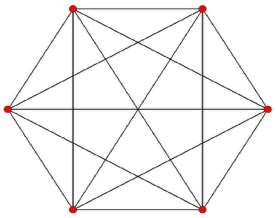
3.6 Properties of Boolean Algebra

Boolean Algebra is a mathematical system consisting of a set of two or more distinct elements, two binary operations denoted by the symbol (+) and (.) , and one unary operator denoted by the symbol either bar(-) .This satisfy the commutative, associative, distributive, absorption, consensus and idemotency properties of the Boolean algebra. A great mathematician De Morgan has contributed with two of the most important theorems of Boolean algebra .De Morgan's theorems are extremely useful in simplifying expression in which a product of sum of variables is complimented.

Boolean algebra has been applied in search engines such as Google and duckduckgo use boolean algebra to facilitate the users to get data whenever they request or search. Logic gates are employed in microcontrollers, microprocessors, electronic and electrical project circuits, and embedded system applications. The basic logic gates are categorized as AND, OR, XOR, NAND, NOR, XNOR, and NOT and these digital devices are based on the Boolean function

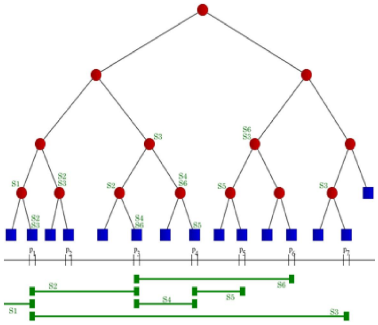
3.7 Graph Theory

A Swiss Mathematician Leonhard Euler introduced this theory in 18th century. Generally graphs are discrete structures which have vertices. In the present era, life graphs are used to solve many problems in different areas like computers, engineering science, communication and so on. The graph models of computer networks can be used to determine whether two computers are connected by a communication link. Also, graphs are used to solve the problem of finding the shortest path between two cities in a transportation network.



3.8 Trees

An English Mathematician Arthur Cayley introduced the concept of trees , when he used these to count certain type of chemical compounds .These are particularly useful in computer science ,when they are employed in a wide range of algorithms .For instance ,tree are used to construct efficient algorithm for locating items in a list .



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3.9 Cryptology

Everyone knows that secret message have been sent from an ancient age to present era of Science and technology. Classically, these messages are used for secret communication in military affairs, electronic banking and diplomacy. It is an interesting technique which makes messages unintelligible to everyone except the intended receiver .The discipline devoted to secrecy system is called cryptology which is based on the branch of mathematics (number theory).

3.10 Statistics

It is a branch of mathematics and involved in computer science to a great extent. The knowledge in field of statistics is unavoidable to understand algorithms and other statistical properties that are needed in computer science. Some statistical measures relate with mean, mode, skewness, regression analysis, variance, kurtosis. Probability and Statistics for Computer Science treats with the most common discrete and continuous distributions, disclosing how they find use in decision and estimation problems and devise computer algorithms to generate observations from the multifarious distributions.

The knowledge of statistics is supportive for data mining, speech recognition, vision and image analysis, data compression, artificial intelligence, network and traffic modelling to varying extent as per requirement of researchers / scientists like as follows

- **Data Mining:** It is an analysis of information in a database, using tools that look for trends or irregularities in large data sets. In other words "to find valuable information from the available data sets using statistical techniques".
  Data Compression: It is the coding of data by usage of compact formulas, called algorithms, and usefulness to save storage space or transmission time.
- **Speech Recognition:** It is an act of identifying spoken words by a machine. The spoken words are transformed into a sequence of numbers and matched against coded dictionaries.
- **Vision and Image Analyses:** Vision and image analysis also require statistics to solve contemporary and practical problems/ queries in computer vision, image processing, and artificial intelligence.
- **Stochastic Algorithms:** Stochastic algorithms follow a detailed sequence of actions to perform a task in the face of uncertainty.
- **Artificial Intelligence:** It is implicated with modelling aspects of human thought on computers.
- **Machine Learning:** It is the ability of a machine or a system to enhance or make progress in its performance based on previous results.
- **Capacity Planning:** Capacity planning finds out what equipment and software will be enough to face the needs of a situation or a proposed end while providing the most power for the least cost.
- **Storage and Retrieval:** Storage and retrieval techniques are dependent on statistics to make sure computerized data is kept and recovered efficiently and reliably.
- **Quality Management:** It uses statistics to make analysis the condition of manufactured parts (hardware, software, et.al..) using tools and sampling to make sure a minimum level of defects.
- **Software Engineering:** It is a systematic approach to the analysis, design, implementation, and maintenance of computer programs.

3.11 Calculus

The study of continuous change of functions come under purview of calculus. If someone wants to work in these professions, he/she must have some knowledge of calculus. The subthemes of Computer Science such as machine learning, data mining, scientific computing, image processing, and creating the graphics and physics engines for video games, including the 3D visuals for simulations, the aforesaid subject is supportive. Both differential and integral calculus that are two major concepts of calculus contribute much in the area of computer graphics, scientific computing, and computer security. Computer scientists also take help of multivariate calculus.

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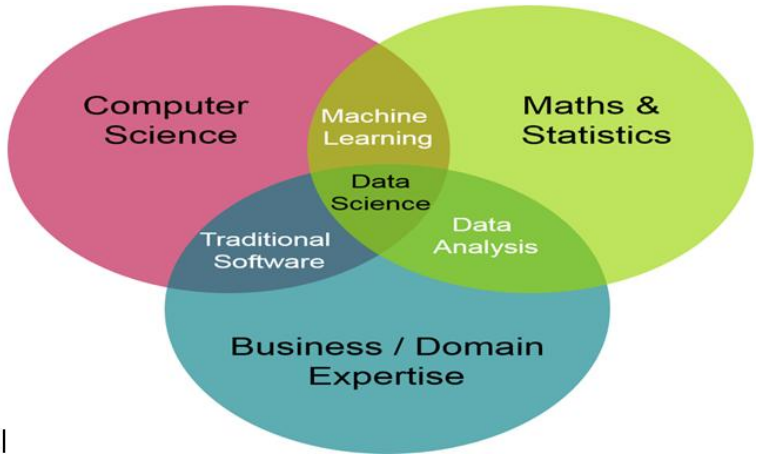
IV. DISCUSSION

No doubt, one can say that Computer Science is the subset of Mathematical Sciences. Discrete mathematics, linear algebra, number theory, and graph theory are the branches of mathematics, the most relevant to the computer science profession. Different fields of the profession, from machine learning to software engineering, apply concepts of these branches of mathematics in one way or other. Without having familiar with these maths concepts, one may find himself in trouble to manage data structures, databases, and algorithms.

V. CONCLUSION

Does Mathematics really important for Computer Science? It is an open ended question. One can say that it depends upon kind of job. For instance: Creating a blog on food does not necessarily need any knowledge of mathematics. But to design a successful blog needs emphasis on preferences of audience, popularity of topic, article ratings, etc.

Skills of Mathematics are utilised in the field of Computer Engineering in almost all of its programs but still there is much more to learn with the emergence of new concepts of machine learning, artificial intelligence et.al.. Over all, directly or indirectly prowess in Mathematics is must for the foundation of Computer Science. If someone wants to succeed in any discipline of Computer Science, he/she must inculcate acumen of Mathematics to progress ahead.



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