Discrete Mathematics: As A Spine of Computer Science

Dr. Ramesh Prasad Aharwal

Assistant Professor, Department of Mathematics and Computer Application
Govt. P.G. College Damoh (M.P.) India

ABSTRACT: Discrete mathematics is the branch of Mathematics. It deals with objects than can have different values. It is also called decision mathematics. At the most fundamental level, all of a computer's data is represented as bits 0 and 1. Computers make calculations by modifying these bits in accordance with the laws of Boolean algebra, which form the basis of all digital circuits. This paper deals with the importance of discrete mathematics in computer science. In this regards, this study have focused about evolution of discrete mathematics, terminologies and some important applications of discrete mathematics in Computer Science.

Keywords: Graph theory, Cryptography, Boolean algebra, Set theory

I. INTRODUCTION

The concept of discrete mathematics found in many branches of mathematics and its application are also found in other disciplines such as Information theory, Electrical Engineering, in statistical Physics, Chemistry, and Molecular biology and mainly used in Computer Science. Combinatorial topics of discrete mathematics such as combinatorial set theory, graph theory, Group theory, cryptography and other related topics are related to a large part of the mathematical and science worlds. Topics in number theory such as recurrence relations and congruence are also considered as the part of discrete mathematics. The study of topics in discrete mathematics usually includes the study of algorithms their implementations. Discrete mathematics is the mathematical language of computer science, and as such, its importance has increased dramatically in recent decades. Discrete Mathematics also provides an essential foundation for virtually every area of computer science, and its applications are correspondingly vast. The numerous applications of these topics also found in other fields. In this paper we have discussed the application and importance of related topics of discrete mathematics in computer science such as Game theory, number theory, set theory, Boolean algebra and cryptography [8]. Author have been downloaded some research papers regarding application of mathematics in computer science and read them. After that we observed that discrete mathematics is as a spine of computer science.

II. BOOLEAN ALGEBRA IN COMPUTER SCIENCE

In 1854, Boole published a classic book, "An Investigation of the Laws of thought" on which he founded the Mathematical theories of Logic and Probabilities, Boole‟s system of logical algebra, now called Boolean algebra [12]. Boolean algebra derives its name from the mathematician George Boole (1815-1864) who is considered the "Father of symbolic logic". It is a sub topics of discrete mathematics. It deals with binary number system is called "Boolean Algebra" which is very power in designing logic circuits used by the processor of computer system. It is also called as "Switching Algebra". There are so many applications of Boolean algebra apart from them such as Digital circuit, Google search, Database and Programming.

III. GRAPH THEORY IN COMPUTER SCIENCE AND APPLICATIONS

The origin of graph theory started with the problem of Koinsber bridge, in 1735. Graph theory is the branch of discrete mathematics. It is the study of graphs which are structured used to a model as a pair wise relation among the objects.[4]. Theoretical ideas of graph theory highly utilized by computer science and applications. Such as Computer Networking, google search, google map, Computer network security. Especially in research areas of computer science such data mining, image segmentation, clustering, image capturing, networking. There are so many research papers and research articles, regarding applications of graph theory in computer science, computer applications, have been published in national and international levels. Some research papers and articles are [1][2][7][6] deals with Graph theory in many other fields of Computer science [6].

Graph theory is having its application in modeling, Networking security to keep data safe., Used for representing and analysis of Social networking sites , Application in data and Communications networks , Used in Information network, Developers used Software design to represent different modules, In Transportation networks , In the field of Artificial Intelligence , In solving problem of neural network. Sub topics of graph theory such as graph coloring, spanning tree, tree, shortest path algorithms, traveling salesman problem, etc are all used in computer science. These topics are used in data structure, Artificial intelligence, and operating system. Description of applications of graph theory in computer applications are followings:

Map Networks: the concept of graph theory mostly used to develop the algorithms in computer science. Apps such as Maze, Google Maps, Apple Maps, and Uber are installed on all smartphones. Navigation problems are modelled like graph problems. Think of examples like travelling merchant problems, shortcut problems, Hammington routes, etc.[9]

Blockchains: The vertices are blocks, each holding multiple transactions, and the edges connect the following blocks. The largest branch from the first block is the current standard for historical transactions [9].

IV. SET THEORY IN COMPUTER SCIENCE

Set theory is not only important in mathematics, but it also plays a crucial role in computer science. It is used in data structure, database management system, software engineering. The origins of set theory can be traced back to the 19th century, when German mathematician Georg Cantor first introduced the concept of infinite sets. His work sparked a revolution in mathematics, as it opened up new possibilities for understanding the properties of infinity and the nature of mathematical entities. In programming languages, set notation is also used to represent and manipulate sets of data. Many programming languages such as Python and Java have built-in set data types that are based on set theory. These sets can be manipulated using set operations such as union, intersection, and difference, making it easy to perform complex set-based operations in your code.

V. DISCRETE MATH IN CRYPTOGRAPHY

The term Cryptography, coined from the Greek language. It is collaboration of two words 'kryptos'- 'hidden' and 'graphein'- 'to write'. It came into picture when the use of physical locks was abandoned in communication. The first recorded use of cryptography comes from Julius Caesar, a Roman army commander, around 50 B.C [5]` Cryptography is the branch of discrete mathematics. The field of cryptography, which is the study of how to create security structures and password for computers and other electronic systems. It is totally based on discrete mathematics. Cryptography is the science of using mathematics to encrypt and decrypt data. Cryptography is one of the essential fields in today's digital era, where online security is a big concern. A message sent from a sender to receiver in online communication has the risk of being seen by an unknown person without proper safety. This problem is solved by the use of the concept of encryption/decryption. The message which is sent by the sender is said to be 'encrypted' or encoded with the help of a large number, usually prime, which is said to be a 'key'; the receiver must have that same key to 'decrypt' or decode the message.

Cryptography enables you to store sensitive information or transmit it across insecure networks (like the Internet) so that it cannot be read by anyone except the intended recipient. There are so many sub topics of discrete mathematics are used in Cryptography such as group theory, set theory, number theory and so on. Actually cryptography involve algorithms and all algorithms are based on mathematics.

Cryptography have some terminology such as cipher text, plaintext, encryption, decryption which are defined in briefly as follows [3]

Plain Text: The confidential data that should be secured while transmission is referred as plain text.

Cipher Text: The transformed plain texts that cannot be understand without applying encryption algorithm and encryption key over the plain text.

Encryption Algorithm: It is a mathematical process which is used to convert plain text into cipher text using some encryption key.

Decryption Algorithm: This is the reverse process of encryption algorithm. To produce the original text we use cipher text and encryption algorithm.

VI. NUMBER THEORY IN COMPUTER SCIENCE

Number theory is a broad and diverse branch of mathematics that deals with integers and their related objects. A number theory can be applied to a wide range of scientific and mathematical problems, and it has enormous significance in many fields of mathematics and Computer science. There are many surprising connections between the theory of numbers, which is one of the oldest branches of mathematics, computing and information theory. Number theory has significant applications in computer science and security, coding and cryptography, random number generation, hash functions, Block chain and graphics [10][8]. Number theory also has memory-related uses in computer architecture and operating systems [8]. The number theory, combined with the computational power of modern computers, gives interesting solutions to real-life problems. It has many uses in various fields such as cryptography, computing, numerical analysis and so on. Number theory in quantum computing. Number theory, known as the queen of mathematics is the branch of mathematics that concerns about the positive integers 1, 2, 3, 4, 5 which are often called natural numbers and their appealing properties.

VII CONCLUSION

No doubt, we can say that Computer Science is the subset of Mathematical Sciences. Discrete mathematics and its sub topics such as graph theory, Boolean algebra, set theory and other sub topics are very useful in computer science. In this paper, the author has tried to show the importance and applications of various sub-topics of Discrete Mathematics in computer science. In this paper we have discussed the application of sub topics of discrete mathematics in computer science.

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