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Recent Advances in Graph Theory and its Applications.

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ABSTRACT
The field of mathematics plays vital role in various fields. One of the important areas in mathematics is graph theory which is used in structural models. This structural arrangement of various objects or technologies lead to new inventions and modifications in the existing environment for enhancement in those fields.This paper describe the description of graph theory.

Keywords: Graphs, connectivity, constraints, graph coloring, graph drawing

INTRODUCTION

Graph theory is a branch of discrete mathematics. In mathematics and computer science, graph theory is the study of graphs which are mathematical structures used to model pair wise relations between objects. There is wide use of graphs in providing problem solving techniques, because it gives an intuitive manner prior to presenting formal definition. To analyze the graph theory application two problem areas are considered.

1- Classical problem
2- Problems from applications

the classical problem are defined with the help of the graph theory as connectivity, cuts, paths and flows, coloring problems and theoretical aspect of graph drawing. Whereas problems from application particularly emphasis on experimental research and the implementation of the graph theory algorithms. Graph drawing is a key topic in implementation point of view, because the automatic generation of drawing graph has important applications in key

computer science technologies such as data base design, software engineering, circuit designing, network designing and visual interfaces.

Graph theoretical ideas are highly utilized by computer science applications. Especially in research areas of computer science such data mining, image segmentation, clustering, image capturing, networking etc., For example a data structure can be designed in the form of tree which in turn utilized vertices and edges. Similarly modeling of network topologies can be done using graph concepts. In the same way the most important concept of graph coloring is utilized in resource allocation, scheduling. Also, paths, walks and circuits in graph theory are used in tremendous applications say traveling salesman problem, database design concepts, resource networking. This leads to the development of new algorithms and new theorems that can be used in tremendous applications.

A. Graphs Theory

Graphs provide a convenient way to represent various kinds of mathematical objects. Essentially, any graph is made up of two sets:

1- A set of vertices

2- A set of edges.

Depending on the particular situation, restrictions are imposed on the type of edges we allow. For some problems directed edges are applied and for other problem undirected edges are applied from one vertex to other. So graphs give us many techniques and flexibility while defining and solving a real life problem. Graphs has many features, some of them are:

- Provides abstracted view
- Establishes relationship among objects
- Balancing
- Modeling
- Decision -making ability
- Structural arrangement of various objects
- Easy modification or change in the existing system

B. History of Graph Theory

The origin of graph theory started with the problem of Koinsber bridge, in 1735. This problem lead to the concept of Eulerian Graph. Euler studied the problem of Koinsberg bridge and constructed a structure to solve the problem called Eulerian graph. In 1840, A.F Mobius gave the idea of complete graph and bipartite graph and Kuratowski proved that they are planar by means of recreational problems. The concept of tree, (a connected graph without cycles) was implemented by Gustav Kirchhoff in 1845, and he employed graph theoretical ideas in the calculation of currents in electrical networks or circuits. In 1852, Thomas Gutherie found the famous four color problem. Then in 1856, Thomas. P. Kirkman and William R.Hamilton studied cycles on polyhydra and invented the concept called Hamiltonian graph by studying trips that visited certain sites exactly once. In 1913, H.Dudeneymentioned a puzzle problem. Eventhough the four color problem was invented it was solved only after a century by Kenneth Appel and Wolfgang Haken. This time is considered as the birth of Graph Theory.

APPLICATION OF GRAPH THEORY IN COMPUTER SCIENCE

Graph theory is playing an increasingly important role in the field of computer science. Any software that has to be developed, any program that has to be tested is making themselves easy using graphs. Its importance is derived from the fact that flow of control and flow of data for any program can be expressed in terms of directed graphs. Graph theory is also used in microchip designing, circuitry, scheduling problems in operating system, fi le management in database management system, data flow control between networks to networks. The theory of graphs had made the field of computers to develop its own graph theoretical algorithms. These algorithms are used in formulating solutions to many of computer science applications.

Some algorithms are as follows:

- Shortest path algorithm in a network
- Kruskal's - minimum spanning tree
- Euler's- graph planarity
- Algorithms to find adjacency matrices.
- Algorithms to find the connectedness
- Algorithms to fi nd the cycles in a graph
- Algorithms for searching an element in a data structure (DFS,BFS) and so on.

A. Network system

Graph theory has wide application in the field of networking. To analyze the graph theory application in networking two areas are considered: graph based representation and network theory. Graph based representation has many advantages such as it gives different point of view; it makes problem much easier and provide more accurate definition. Whereas network theory provide a set of techniques for analyzing a graph and applying network theory using a graph representation. The term graph and network are equal. Both refer to a type of structure in which there exists vertices (i.e. nodes, dots) and edges (i.e. links, lines). There are numerous types of graphs and networks which yield more or less structure. These two terms can be differentiating on the basis of their utility. the term graph is used in mathematics whereas the term network is used in physics.

B. Data Structure

Data may be organized many different ways. The logical or mathematical model of a particular organization of data is called a "data structure". The choice of data model depends on two considerations:

- It must be rich enough in structure to mirror actual relationship of data in real world.
- The structure should be simple enough that one can effectively process data when necessary.

These two considerations is fulfilled by the graph theoretical concepts. Arbitrary relation among data can also be represented by a graph and its matrices , operations performed on these metrics are further useful for deriving relations and data association and is useful in order to understand how these data may be stored in memory.

C. Communication Network

The graph theoretical ideas are used by various computer applications like data mining, image segmentation, clustering, image capturing, networking etc. Graph theory can be used to represent communication networks. A communications network is a collection of terminals, links and nodes which connect to enable telecommunication between users of the terminals. Each terminal in the network must have a unique address so messages or connections can be routed to the correct recipients. The collection of addresses in the network is called the address space. Every communications network has three basic components: terminals(the starting and stopping points of network), processors(which provide data transmission control functions), transmission channels(which help in data transmission). The communication network aims to transmit packets of data between computers, telephones, processors or other devices. The term packet refers to some roughly fixed-size quantity of data, 256 bytes or 4096 bytes. The packets are transmitted from input to output through various switches. The communication networks can be represented using the various mathematical structures which also help us to compare the various representations based on congestion, switch size and switch count. Graphs have an important application in modeling communications networks. Generally, vertices in graph represent terminals, processors and edges represent transmission channels like wires, fibers etc. through which the data flows. Thus, a data packet hops through the network from an input terminal, through a sequence of switches joined by directed edges, to an output terminal.

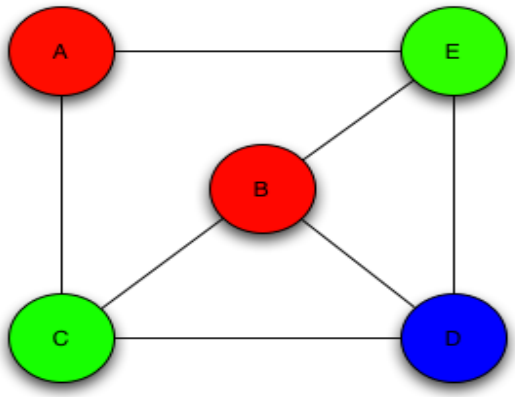
D. Graph Coloring

Graph coloring especially used various in research areas of computer science such data mining, image segmentation, clustering, image capturing, networking etc., For example a data structure can be designed in the form of tree which in turn utilized vertices and edges. Similarly modeling of network topologies can be done using graph concepts. In the same way the most important concept of graph coloring is utilized in resource allocation, scheduling. Also, paths, walks and circuits in graph theory are used in tremendous applications say traveling salesman problem, database design concepts, resource networking. This leads to the development of new algorithms and new theorems that can be used in tremendous applications. Graph coloring is one of the most important concepts in graph theory and is used in many real time applications in computer science. Various coloring methods are available and can be used on requirement basis. The proper coloring of a graph is the coloring of the vertices and edges with minimal number of colors such that no two vertices

should have the same color. The minimum number of colors is called as the chromatic number and the graph is called properly colored graph.

Vertex coloring is the most common graph coloring problem. The problem is, given m colors, find a way of coloring the vertices of a graph such that no two adjacent vertices are colored using same color. The other graph coloring problems like Edge Coloring (No vertex is incident to two edges of same color) and Face Coloring (Geographical Map Coloring) can be transformed into vertex coloring.

Chromatic Number**:** The smallest number of colors needed to color a graph G is called its chromatic number. For example, the following can be colored minimum 3 colors.



The graph coloring problem has huge number of applications as follows:

1) Making Schedule or Time Table: Suppose we want to make am exam schedule for a university. We have list different subjects and students enrolled in every subject. Many subjects would have common students (of same batch, some backlog students, etc). How do we schedule the exam so that no two exams with a common student are scheduled at same time? How many minimum time slots are needed to schedule all exams? This problem can be represented as a graph where every vertex is a subject and an edge between two vertices mean there is a common student. So this is a graph coloring problem where minimum number of time slots is equal to the chromatic number of the graph.

2) Mobile Radio Frequency Assignment**:** When frequencies are assigned to towers, frequencies assigned to all towers at the same location must be different. How to assign frequencies with this constraint? What is the minimum number of frequencies needed? This problem is also an instance of graph coloring problem where every tower represents a vertex and an edge between two towers represents that they are in range of each other.

3) Suduku: Suduku is also a variation of Graph coloring problem where every cell represents a vertex. There is an edge between two vertices if they are in same row or same column or same block.

4) Register Allocation: In compiler optimization, register allocation is the process of assigning a large number of target program variables onto a small number of CPU registers. This problem is also a graph coloring problem.

5) Bipartite Graphs: We can check if a graph is Bipartite or not by colowing the graph using two colors. If a given graph is 2-colorable, then it is Bipartite, otherwise not. See this for more details.

6) Map Coloring: Geographical maps of countries or states where no two adjacent cities cannot be assigned same color. Four colors are sufficient to color any map.

E. Operating System

A graph is a data structure of finite set of pairs, called edges or vertices. Many practical problems can be solved with the help of graph in the field of operating system such as job scheduling and resource allocation problems. For example graph coloring concept can be applied in job scheduling problems of CPU, jobs are assumed as vertices of the graph and there will be an edge between two jobs that cannot be executed simultaneously and there will be one to one relationship between feasible scheduling of graphs.

Graph purpose in operating system:

- System processes are represented in graph form.

- Graph extraction techniques are used in event tracing.
- Excellent testing tool in performance evaluation because of easy validation and modification.

F. Image Processing

Image Analysis is the methodology by which information from images is extracted. Image analysis is mainly performed on digital image processing techniques. The image processing techniques can be improved using a graph theoretic approach. The applications of graphs in image processing are: to find edge boundaries using graph search algorithms in segmentation.

- To calculate he alignment of the picture.
- Finding mathematical constraints such as entropy by using minimum spanning tree.
- Finding distance transforms of the pixels and calculates the distance between the interior pixels by using shortest path algorithms.

G. Software Engineering

Graph has many applications in software engineering. For example: during Requirements Specification, Data Flow diagrams are used where vertices represent transformations and edges represents the data flows. During Design phase, graphical design is used for describing relations among modules; while during Testing, the control flow of a program associated with McCabe's complexity measure which employs directed graphs for addressing the sequence of executed instructions and etc. Even Software Process Management has also applications of network diagrams which involves graph algorithms.

H. Data base Designing

In data base designing graphs are used as graph data bases. Graph database uses graph representation with nodes, edges, and properties to represent and store data. This graph structure has key role in designing database, because it gives fast implementation process using different functionality and properties of graph structure .Graph database uses as:

- Storage system that provides index free adjacency
- Analyzing tool for interconnection
- Powerful tool for graph like-query
- Graph databases are often faster for associative data sets that map more directly to the structure of object-oriented applications.

I. Website Designing

Website designing can be modeled as a graph, where the web pages are represented by vertices and the hyper links between them are represented by edges in the graph. This concept is known as web graph. Which discover the interesting information? Other application areas of graphs are in web community. Where the vertices represent classes of objects, and each vertex representing one type of objects, and each vertex representing a type of object is connected to every vertex representing other kind of objects. In graph theory such a graph is called a complete bipartite graph. There are many advantages of using graph representation in website development such as:

- Searching and community discovery.
- Graph representation (directed graph) in web site utility evaluation and link structure.
- Finding all connected component and provide easy detection.

CONCLUSION

The main aim of this paper is to present the importance of graph theoretical ideas in various areas of computer applications. This paper is designed to benefit the students of computer science to gain depth knowledge on graph theory and its relevance with other subjects like operating systems, Networks, Databases, software engineering etc. this paper focused on the various applications of major graph theory that have relevance to the field of computer science and applications.

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