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Applications of Computer Science Based on Graph theory

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Abstract

The field of mathematics plays an essential role in different domains. In various areas of graph theory is employed in several applications of technology. Graphs are considered as an outstanding modeling tool which is utilized to model several classes of relations amongst any physical scenario. Several issues of the real world can be represented by graphs. This paper explores varied ideas concerned in graph theory and their applications in computer science to demonstrate the utilization of graph theory. These applications are given particularly to project the thought of graph theory and to demonstrate its objective and importance in computer science engineering.

Keywords:

Graphs, Graph Theory, Computer Science and Applications

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1. Introduction

In mathematics, graph theory is a branch of discrete mathematics. Study of graphs is known as Graph theories which are mathematical structure utilized to model pairwise relations between objects. There is a

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huge utilization of graphs in mathematics and computer science to providing problem solutions because it gives a sensitive approach prior to presenting formal definition [1] [2]. Two problem areas are considered to analyze the applications of graph theory. They are classical problem and application problems.

The classical problem is defined with the help of the graph theory as connectivity, cuts, paths and flows, coloring problems and theoretical aspects of drawing graphs [2]. The application problems are an emphasis on experimental research and the implementation of the graph theory algorithms. Implementation point of view is the main topic in graph drawing. Graph drawing plays an important role for automatic graph generation in computer science technology applications such as database design, software engineering, circuit designing, networks and data mining.

Graph theory history:

Graph theory is basis with an issue of Koinsber Bridge by L Euler Swiss mathematician in 1735. Konigsberg is a small town located on the European continent. In the city, there is a big river and there are two deltas. The issue of Koinsberg Bridge was studied by Euler and constructed a graph structure to resolve the issue known as the Eulerian graph shown in figure 1.

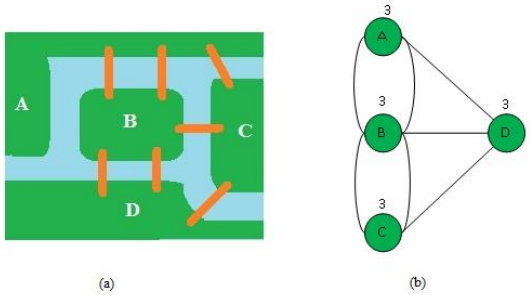

Figure1. a. Konigsberg Bridge b. Konigsberg Bridge representation in graph

Graph theory origin was considered by following things. A.F. Mobius offered the concept of a complete graph and bipartite graph in 1840. Complete and bipartite graphs are planar by means of recreational problems shown by Kuratowski. The concept of a tree, a connected graph without cycles was endorsed by Gustav Kirchhoff in 1845, and he enrolled graph theoretical ideas in the calculation of currents in electrical networks or circuits. The well-known four color problem was introduced in 1852 by Thomas Gutherie. It was proved after a century by Kenneth Appel and Wolfgang Haken. Measuring of cycles on polyhedral and Hamiltonian graph came in the existence in 1856 by Thomas. P. Kirkman and William R. Hamilton. A puzzling problem was mentioned by H. Dudeney in 1913.

PRELIMINARY

Before, understand the application of graph in various domains we need to know some basic definition that is constituted of graph theory. Authors of this paper have identified these definitions and have represented it in a simple to understand mode [4].

Graph: In general graph G consists of two things:

1. The set of vertex V, whose elements are called vertices (or) nodes
2. The set of edges E, connecting a pair of vertices.

Directed and Undirected graph: An undirected graph is graph G (Figure 2), which is connected together, where all the edges are bidirectional. A Directed graph is graph G, which is connected, where all the edges are a point in a direction.

Adjacency matrix: An adjacency matrix is a square matrix utilized to be a symbol of a finite graph. The elements of the matrix with respective of graph identify whether the pair of vertices are adjacent or not. Example of the adjacency matrix is shone in figure 2.

The Degree of a vertex: In an Undirected graph, number of edges that are an occurrence to the vertex or node is called the degree of the vertex. In directed graph having in-degree and out-degree concept, the number of edges occurrence to a vertex is called in-degree whereas a number of edges moving from the vertex are called out-degree. The degree of a vertex is shown in figure2.

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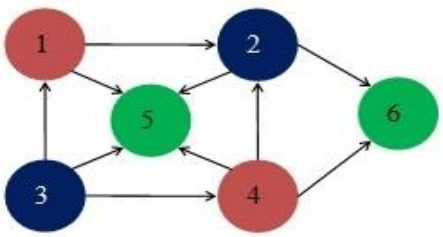


(a)

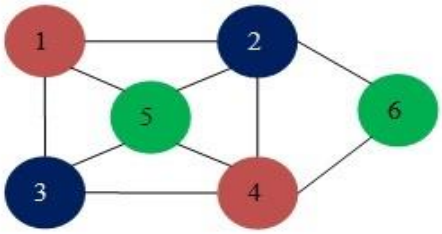
V = {1, 2, 3, 4, 5, 6}
E ={(1,2) (1,5) (2,5)(2,6)(3,1)(3,4)(3,5)(4,2)(4,5)(4,6)}

Degree:

Vertex	In-Degree	Out-degree
1	1	2
2	2	2
3	0	3
4	1	3
5	4	0
6	2	0

Adjacency matrix

-	1	2	3	4	5	6
1	0	0	0	0	1	0
2	1	0	0	0	1	1
3	1	0	0	1	1	0
4	0	0	0	0	1	1
5	0	0	0	0	0	0
6	0	0	0	0	0	0



(b)

V = {1, 2, 3, 4, 5, 6}
E ={(1,2) (1,3) (1,5)(2,4)(2,5)(2,6)(3,5)(4,5)(4,6)}

Vertex	Degree
1	3
2	4
3	3
4	4
5	4
6	2

-	1	2	3	4	5	6
1	0	1	1	0	1	0
2	1	0	0	1	1	1
3	1	0	0	1	1	0
4	0	1	1	0	1	1
5	1	1	1	1	0	0
6	0	1	0	1	0	0

Figure 2: a) Directed graph with a number of vertices and edges, the degree of vertex and adjacency matrix.
b) Undirected graph with of vertices and edges, degree of vertex and adjacency matrix

Vertex coloring: An obligation of colors to the vertices of a graph G so that no two adjacent vertices of G have the similar color is called vertex coloring of graph G.

Chromatic number: The minimum number of colors required to color a vertex of a graph G, is known as a chromatic number of graph G.

Tree: A graph which is connected without any cycles is known as Tree

Bipartite/Bigraph graph: A bipartite graph is a set of vertices partitioned into two disjoint sets such that no two graph vertices within the same set are adjacent. Bipartite graph example is shown in figure 3a.

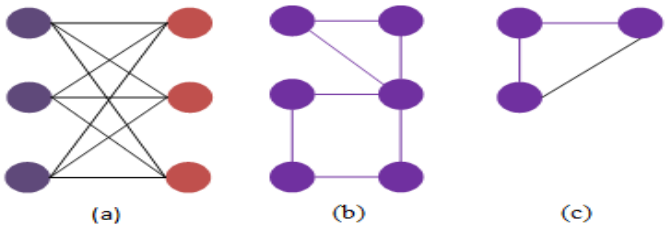


Figure3. a) Bipartite graph b) graph c) subgraph

Spanning Tree: A spanning tree is a subset of Graph G, which has all the vertices covered with a smallest promising number of edges. Hence, a spanning tree is connected and does not enclose any cycles.

Subgraph: A subgraph G'= (V', E') which is a subpart of a graph G=(V, E). The example of Subgraph is shown in figure 3c.

Isomorphic graph: Let G and F are two graphs. Both the graph having different forms with the same number of graph vertices and edges. are said to be isomorphic graphs.

Applications

Graph theoretical originations are generally utilized in branch of knowledge and model various application program, in various fields. In chemistry, it incorporates an investigation of molecules, construction of bonds

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and the study of atoms. Graph theory is utilized in biology and safeguarding of endeavors where a vertex corresponds to regions where certain species exist and the edges compares to movement way. This information is crucial when taking a gander at rearing examples or attaching the spread of disease, parasites and to consider the effect of movement that influences different species. Graph theoretical ideas are broadly utilized in operation research. For example, the traveling salesman problem, the shortest spanning tree in a weighted graph, acquiring an ideal match of employment and men and finding the briefest way between two vertices in a graph. It is likewise utilized in demonstrating transport networks, activity networks, and game theory. To explain countless issues by using network activity. The most popular and successful applications of networks in operation research is the planning and scheduling of large complicated projects [4]. The best well-known problems are PERT (Project Evaluation Review Technique) and CPM (Critical Path Method). Next, game theory is applied to the problems in engineering, economics, and war science to find an optimal way to perform certain tasks in competitive environments. To represent the method of a finite game a digraph is used. Here, the vertices represent the positions and the edges represent the moves. Various applications in different areas are shown in figure4.

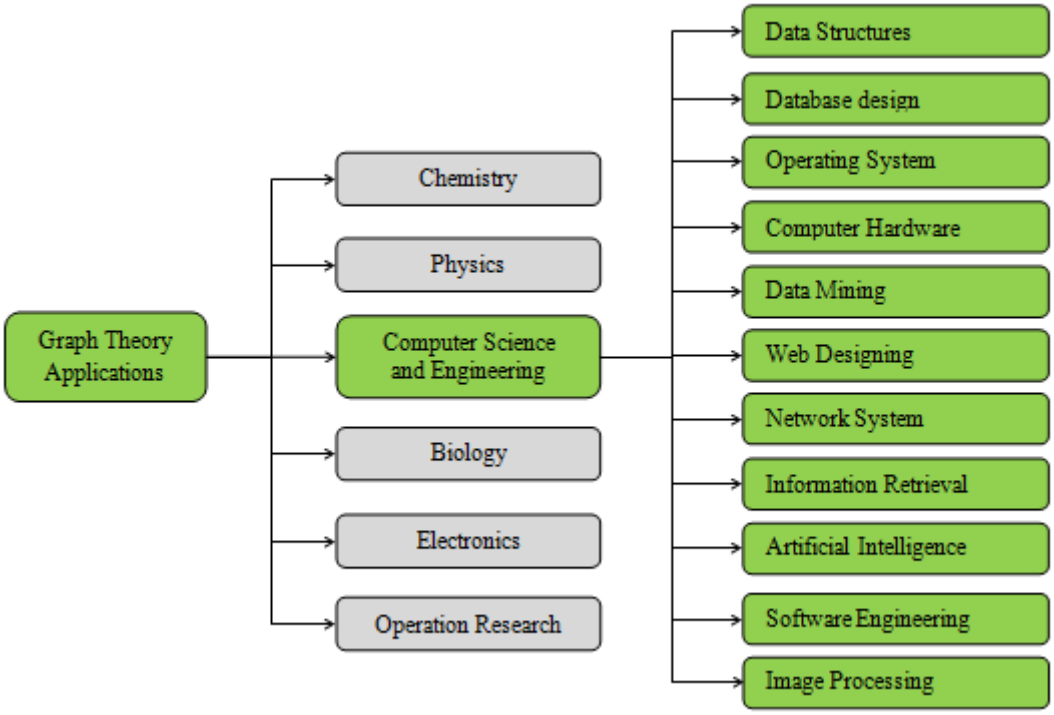

Figure 4. Graph theory applications in various fields

Application in Computer Science

Database Design:

Graphs are utilized in designing the database [5]. Graph database utilizes a representation of a graph with nodes, edges, and properties to represent and store data. This graph structure plays an important role in the designing database because it provides quick process implementation using different functions and properties of the graph. A graph database uses as, providing index fee adjacency system to store, Interconnections can be evaluated using the tool, 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.

Data Structure:

Data may be organized many different ways. The logical or mathematical model of a specific organization of data is called a "Data Structure". The selection of data model depends upon two deliberations:

1. It must be rich enough in structure to represent the actual relationship of data in the real world.
2. The structure should be an adequate that one can effectively process data when necessary.

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These two considerations are fulfilled by the graph theoretical concepts. The 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 are used in order to understand how these data may be stored in memory.

The algorithms of graph theory is involved in are

a) Searching graphs by utilizing Breadth-first Search and Depth-first search
b) Shortest Path Algorithms
c) Minimum spanning tree algorithm
d) Detecting cycles in graphs

Computer Hardware:

Graph theory concepts are utilized in computer hardware to model the limitations of the physical layer [6].

1. Graph coloring is utilized to allocate a register
2. Adjacency matrix is used for representing of sequence of instructions
3. Processing parallel instructions
4. Allocation of process scheduling.

Operating System:

Many practical problems can be solved with the help of graph data structures in the field of an operating system such as job scheduling, resource allocation problems. For example, graph coloring concept can be applied in job scheduling problems of CPU, jobs are assumed as nodes of the graph and edge between two jobs that cannot be executed simultaneously and there will be one to one relationship between the feasible scheduling of graphs.

Data Mining:

Graph theory is the major application area of graph theory in data mining. Graph mining represents the relational aspects of data. The theoretically based approaches to graph-based data mining. They are subgraphs, subgraph isomorphism, graph invariants, mining measures and solution methods. For example, automated text analysis and text mining [7] methods have received a great deal of attention because of the remarkable increase of digital documents. Currently, we can store, organize and retrieve information in text documents automatically without looking at printed documents. Automated text analysis and text mining are becoming more and more in computer applications. Models are represented in the graph have the ability to catch auxiliary data in writing however they don't consider the semantic relations between words [8].

Web Designing:

Web designing can be represented as a graph. Where the web pages are symbolized as vertex and the hyperlinks between then are symbolized as edges in the graph. This representation is acknowledged as a web graph. It discovers the interesting information. Another application is web community. Where the vertices represent classes of objects and each vertex representing one type of objects, and every vertex representing a type of object is connected to each vertex representing a new type of objects. In graph theory, such a graph is called a complete bipartite graph. Website development using graph representation having various advantages such as searching and discovery of community, directed graph representation in website utility of evaluation and link structure and discovering all connected component and provide easy detection.

Network Systems and security

Graph theory accepts a vital part in various territories. Graph theory assumes a critical part of the investigation of these essential issues in Mobile ad-hoc networks (MANETs). MANETs dependably brings the consideration of research group [9]. The Graph theory concepts identified to connectivity, scalability, routing and topology controls in MANETs. The solutions of MANETs in Graph theory is graph spanners, the proximity of graph. By utilizing graph spanners one can decide a few graph spanners, which are helpful in planning the certain class of routing algorithms, the investigation of network clustering, partitioning, and network topology control. One of the troubles in managing graph spanners in an ad-hoc network is how the algorithm can be made distributed with less complexity? The concept of proximity is additionally defined by graph spanners. A

lot of work is done in devising algorithms to construct the graph spanners locally. The studies of proximity graphs assume a vital role in topology control, availability of the network. Proximity represents the neighbor relationship between nodes. Two hubs are joined by a connection in the event that they are regarded near to some proximity measure. This positively influences the network connectivity. The measure decides the sort of a graph that outcomes. The essential ones are Unit Distance Graph (UDG), Nearest Neighbor Graphs (NNG), Minimum Spanning Trees (MST), Relative Neighborhood Graphs (RNG), Delaunay Triangulation (DT), and Gabriel Graphs.

Information retrieval system:

A network is defined as systems of components that connect or manage each other. Networks can be scientifically spoken to as graphs. Typically, the term 'graph' alludes to diagrammatic portrayals of an arrangement of vertices associated by edges. The network regularly alludes to interconnected frameworks of things or specific sorts of the mathematical concepts of graphs. Graph theoretical approaches to deal with recovery can be followed back by semantic information retrieval, which was trailed by a few variants of conceptual information retrieval and knowledge-based information retrieval. Frequent variants of graph formalisms have been utilized as a part of connectionist ways to deal with information retrieval. However as of late, graph-theoretic applications have been utilized for different applications inside IP, for instance, IR assessment estimations, and re-ranking [12].

Software Engineering:

The graph has many applications in software engineering. For example: during requirements specification, data flow diagrams are used where vertices represent transformations and edges represent the data flow. Amid the design stage, the graphical outline is utilized for depicting relations among modules; while amid testing, the control flow of a program related with McCabe's multifaceted nature measure which utilizes directed graphs for tending to the sequence of executed instructions and etc. Indeed, Even Software Process Management has additionally utilization of network diagrams which involves graph algorithms.

In class-oriented model, graphs can be created based on abstract syntax tree [10]. Here the classes are represented as vertices and relations between the classes as edges and type of relationship represents the weight of the graph. After building a graph we can discover subgraphs of a graph, frequent subgraphs, isomorphic graphs etc by utilizing graph mining algorithms.

Image processing:

Image analysis is the methodology by which information from images is extracted. Image analysis is mainly preferred on digital image processing techniques. The image processing techniques can be improved using a graph-theoretic approach. The graph-based methods for image processing are segmentation, filtering, classification, and clustering [11] [12]. The applications of the graph in image processing are: to find edge boundaries using graph search algorithms in segmentation.

1. To compute the alignment of the picture.
2. Discovering mathematical constraint such as entropy by using minimum spanning tree
3. Shortest path algorithm is utilized to compute the distance between the interior pixels.

Artificial Intelligence:

To develop a model to change word "motion issues" into an algorithmic shape keeping in mind the end goal to be prepared by an intelligent tutoring system (ITS). The qualities of motion issues ought to be ordered first and next, proposing a model for the classifications was passed out. With a specific end goal to tackle all categories of the issues, graph theory including reverse and forward tying methods of artificial intelligence were utilized. By embrace of graph theory into the motion problems and set forward some affirmation that the model unravels roughly the greater part of the motion issues [13].

Conclusion:

The fundamental rationale of this paper is to present the significance of the graph theoretical thoughts in various fields of computer applications for exploring that they can utilize graph theoretical concepts for the examination. An outline is exhibited particularly to extend graph theory. Analysts may make them inspire data to graph theory and its applications in the computer field and get a few contemplations identified with their territory of research.

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