e-ISSN 2320 –7876 www.ijfans.org
Vol.11, Iss.9, Dec 2022

Research Paper

APPLICATION OF GRAPH THEORY IN REPRESENTING AND MODELLING TRAFIC CONTROL PROBLEMS

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Abstract

Application of Graph Theory to Computer Science in Big Networks for Big Data. It provides introduction to Graph theory, Graph theory and Computer Science, Big Networks, Big Data, Big Data Analysis, Big Data Framework technologies, Big Data Tools, Data Mining, Web Mining, Graph Mining, Security and Privacy issues of Big Data, integration of Cloud Computing and Big Data etc. Finally, this chapter provides research motivation and problem statement and background to research

Introduction

Graph Theory

Graph Theory: A pivotal Branch of Mathematics

In mathematics, graph theory is the study of graphs, which are mathematical structures used to model pairwise relations between objects. A graph in this context is made up of vertices, nodes, or points which are connected by edges, arcs, or lines. A graph may be undirected,

e-ISSN 2320 –7876 www.ijfans.org
Vol.11, Iss.9, Dec 2022

meaning that there is no distinction between the twovertices associated with each edge, or its edges may be directed from one vertex to another and for other variations in the types of graph that are commonly considered. Graphs are one of the prime objects of study in discrete mathematics. [1], [51], [63], [64]

A graph $G = (V, E)$ consists of two finite sets and VThe elements of E ae called the vertices V and the elements of E the edges of G Each edge is a pair of vertices. Graphs have natural graphical representations in which each vertex is represented by a point and each edge by a line connecting two points. Figure $A.1$ represents the graph $G = (V, E)$ with vertex set $V = \{1.2.3.4.5\}$ and edge set $E = \{12,23,34,45\}$. [7], [48]

1 2 3 4 5

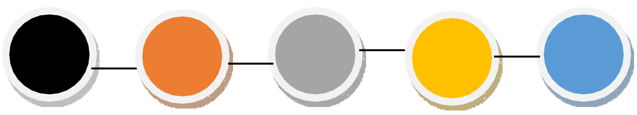

Fig. 1.1 Graph $G = (V, E)$ for above example altering the definition, we can obtain different types of graphs. For instance,

- By replacing the set E to contain both directed graph (digraph for short), also known as an oriented graph. 1
- By allowing containing E both directed and undirected edges, we obtain amixed graph.
- By allowing repeated elements in the set of edges, i.e., by replacing E withmultiset, we obtain a multigraph.
- By allowing edges to connect a vertex to itself (a loop), we obtain a pseudograph.
- By allowing the edges to be arbitrary subsets of vertices, not necessarily ofsize two, we obtain a hyper graph.
- By allowing and V to be E infinite sets, we obtain an infinite graph.

Graph theory Applications

Graph theory has a theory dating back more than 250 years. The era of graph theory started when a famous mathematician, Leonhard Euler had a problem of crossing the seven bridges

e-ISSN 2320 –7876 www.ijfans.org
Vol.11, Iss.9, Dec 2022

of Konigsberg. Ever since he was a child he had a quest for a walk linking seven bridges in Konigsberg. This was today called as the first problem of graph theory Since then, graph theory, the study of graphs with nodes and inter- connections of nodes has evolved and proved with its tremendous use in various fields. It has crept itself into the hands of many famous mathematicians making them easy to solve every complicated real world problem. Its method of representing every problem using pictures or graphs had made itself a pioneer in finding solutions for many unsolved problems. [24], [32]

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 designating, circuitry, scheduling problems in operating system, file 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. [41]

Euler's-graph planarity. Algorithms to find adjacency matrices. Algorithms to find the connectedness. Algorithms to find the cycles in a graph. Algorithms for searching an element in a data structure (DFS, FBS) and so on. Graph theory has its sprawling applications in various fields. It is now viewed as one of the subject of interest that is used for many of real time problem solving. As a theory of graphs it is showing its easiness to represent each real time problem using a visual graph to find the solution. Many of the fields like computer science, business, microbiology, medical etc. Are able to solve existing complicated problems using graphs. [50]

Graph Theory has found applications in varied domains ganging from transportation problems. VLSI design to social networks. Geometric representation of graphs, where nodes

e-ISSN 2320 –7876 www.ijfans.org
Vol.11, Iss.9, Dec 2022

are physical location on the plane or higher dimensional spaces is getting special attention. These are the obvious representations of natural objects like road railway or airlines networks. An edge in a geometric representation has an obvious properly-the length in this article, we discuss about a special aspect of the geometric representation of Graphs-Rigidity of Graph. [60]

Graph Theory and Computer Science

Many problem situations in computer systems can be analyzed using models based ondirected graphs. The vertices of the graph represent states of the system and the directed arcs represent the transitions between these states. This paper is in two parts. The first introduces the concepts of directed graphs and their representations in computers and presents some basic problems and algorithms. The second part examines the application of graph theory to various areas of computer systems. [2] Graphs are considered as an excellent modeling tool which is used to model many type of relations amongst any physical balancing situation. Many problems of real world can be represented by modeling graphs. This paper explores different concepts involved in graph theory and their applications in computer science to demonstrate the utility of graph theory. These applications are presented especially to project the idea of graph theory and to demonstrate its objective and importance in computer science engineering. [5]. 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. These structural arrangements of various objects or technologies lead to new inventions and modifications in the existing environment for enhancement in those fields. The field graph theory started its journey from the problem of Konigsberg bridge in 1735. Thispaper gives an overview of the applications of graph theory in heterogeneous fields to some extent but mainly focuses on the computer science applications that uses graph theoretical concepts. Various papers based on graph theory have been studied related to scheduling concepts, computer science applications and an overview has been presented here. [40] A term big data is now well understood for its well-defined characteristics. More the usage of big data is now looking promising. This chapter being an introduction draws a comprehensive picture on the

e-ISSN 2320 –7876 www.ijfans.org
Vol.11, Iss.9, Dec 2022

progress of big data. First, it defines the big data characteristics and then presents on usage of big data in different domains. The challenges as well as guidelines in processing big data are outlined. A discussion on the state of art of hardware and software technologies required for big data processing is presented. The chapter has a brief discussion on the tools currently available for bi data processing. Finally, research issues in big data are identified. The references surveyed for these chapter introducing different facets of this emergent area in data science provide a lead to intending readers for pursuing their interests in this subject. [45]

Table 1.1: Emerging Technologies of Big Data

Criterion	Waning (past)	Emerging (futuristic)
Storage cost	High. Minimize data by extraction, encoding, and normalizing	Close to zero. Retain as much source data as possible
Storage security	Uncommon. Mostly physical access Control. Once accessed, entire file system is accessible. Granular secure storage only on need basis	Secure and safe storage isexpected by default. Strong logical access control mechanisms
Communication cost	storage only on need basis High	Connectivity is a given and cost is close to zero
Communication security	Optional. Security using crypto algorithms only when needed	Default, e.g., IPv6

e-ISSN 2320 –7876 www.ijfans.org
Vol.11, Iss.9, Dec 2022

Computation	Limitations due to single core and serial algorithms	Multi-core is default and advantages of parallel algorithms
Accessibility	From a single access point with optional backup access/redundancy	From multiple access points and as much redundancy as possible
Data synchronization/ integrity	As provided by the storage provider. Explicit mechanisms needed only if backup/redundancy storage exists	Challenge to be addresseddue to redundant multiple copies

He representation of a relationship in a graph can be reduced to a line, sometimes with a particular weight to indicate strength or volume. But in reality, the underlying relationship often has more nuanced or expansive characteristics than can be shown with a simple line. If the world being displayed is reasonably small, visually expressive links, along with their nodes, can help to more fully explain the nature of relationships.

One type of relationship that is fundamental to data science in virtually any business is correlation. Correlations provide an indication of when and how aspects of a worldare related, which can inform decisions in pursuit of business objectives. Understanding what conditions are most favorable to a particular outcome provides the basis of a strategy for action, influencing the probability of a profitable outcome by manipulating those factors that are within control. Depending on the industry, that strategy might take the form of targeted advertising, adjusting premiums based on a risk assessment, or other actions.

Fig. 1.3 reveals feature relationships in a modern take on a classic data science study known as the Iris lower data set published by Sir Isaac Fisher in 1936. A technique known as a scatter plot matrix is used to plot 50 samples of each of three species of Iris, for each pair

e-ISSN 2320 –7876 www.ijfans.org
Vol.11, Iss.9, Dec 2022

wise combination of four features. He features plotted in each scatter plot are found by following the row and column to the feature labels. He data here represents lower classifications and their features, but it could just as well represent customer classifications and their purchasing or risk characteristics.

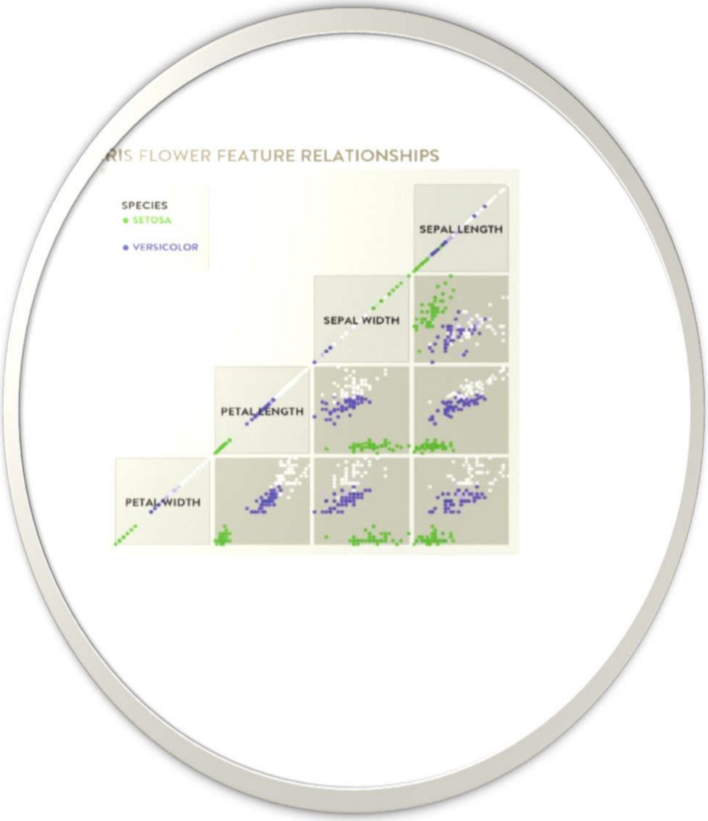

Fig. 1.3: This modern web-based scatter plot matrix chart of the classicIris flowers data set from Sir Isaac Fisher in 1936 shows relationships between features for three species.

All the raw data is shown here, but only two aspects of information can really be taken away

from an analysis of this chart: the defining features for any species and thecorrelations between features, both across and within species. It appears that the species here can be identified primarily by differences in petal width and length, which seem to be strongly correlated, and there also looks to be a correlation of both sepal width and sepal length.

A correlation between petal and sepal length indicates only that both tend to grow in size together, which seems logical and not particularly interesting. If these were correlations between product purchases, however, a known ainity for one class of product would increase the likelihood of ainity for another, indicating value in marketing to those customers.

If you inspect the observed correlations in the lower data set more closely, however, you see significant disparities within species that are not very obvious in the scatter plot matrix.

e-ISSN 2320 –7876 www.ijfans.org
Vol.11, Iss.9, Dec 2022

Figure 1.4 shows correlation matrix charts for both the full data set and all three species individually. he correlations observed across all of the species do not hold within all of the species. Petal length and width are good indicators of species and so are correlated at the global level. But once the species is known, one is not always an indicator of likelihood of the other.

Fig. 1.4: A series of correlation matrices constructed in a spreadsheet reveal how correlations between characteristics vary significantly within subject groups. Here, subject groups are species of Iris flowers but could also be customer profiles.

He same phenomenon occurs in business. For example, statistics may show a correlation between comic book and sports biography purchases. However, the correlation may simply be an indicator that the purchaser is a young male. If it is already known that the purchaser is a man between the age of 18 and 25, there may be no correlation whatsoever, and promoting comics alongside sports bios here would be a waste of time.

e-ISSN 2320 –7876 www.ijfans.org
Vol.11, Iss.9, Dec 2022

Computers are very good at modeling these kinds of relationships and computing the likelihood of other realities or behaviors given a set of known facts. Given a case of a, b, c, a computer can communicate the likelihood of d, e, f. However, without visualization of the nature of the underlying relationships and how they are interconnected, it is difficult for an analyst to gain spiciest enough understanding of the landscape to inform strategic business decisions.

Having each subject represented only once with all of its relationships, in the context of all of the other subjects and their relationships, makes it possible to see how everything is related at the big-picture level. It is also convenient for summarizing important things about each subject in the same context. Here, the distribution of values for each species is drawn in alternating homogenous and heterogeneous rings, summarizing the defining characteristics of each species. Clear radial striations in the Petal Length and Petal Width nodes indicate that they are good features for classifying lowers.

Because graphs can summarize relationships so effectively and so deficiently, they can more easily scale to allow you to show more information. For example, the number of features could easily be tripled in this case, and the big picture would still be evident (and more interesting) in Figure 2-3, easily outdistancing the effectiveness of the matrix charts for doing the same. Graphs are truly unparalleled in their capability to express interconnected relationships. Graph are also a great choice for gaining insights from hierarchical data. Hierarchical graphs are typically referred to as trees. Trees have a root parent node with links branching to a second order of nodes, which may in turn branch again, eventually reaching the leaf nodes that have no children. Each node descendant of the root has a single parent.

Trees have many business applications. Figure 1.5 reframes the Iris lower classification information as a decision tree. A decision tree shows sequences of decisions that lead to particular conclusions. Each node in the tree is a decision, and each link represents 31 a path to follow based on particular criteria.

e-ISSN 2320 –7876 www.ijfans.org
Vol.11, Iss.9, Dec 2022

He Iris decision tree starts with the greatest distinguishing characteristic of each species, which is petal length. All 50 of the Setosa samples can be correctly identified by their characteristically short petals. If the petals are longer, petal width can be measured and an estimate made as to whether they are Virginica or Versicolor. His statistics in this case indicate how many samples will be correctly classified using thisapproach.

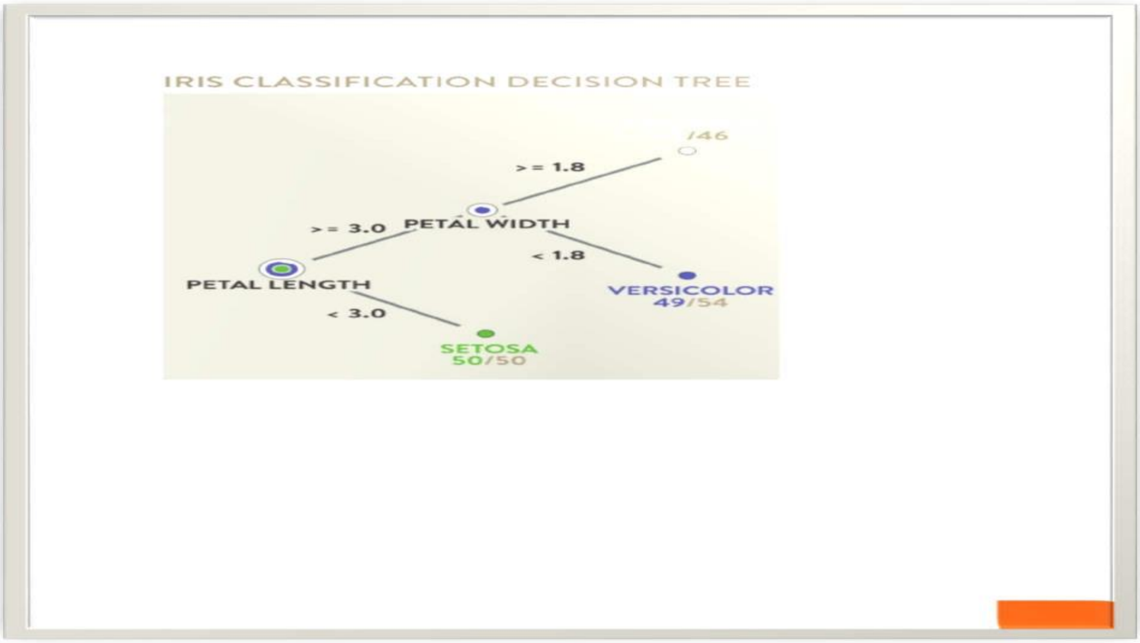

Fig. 1.5: A decision tree articulates a series of branching paths that lead to different conclusions. Here, the flower data set shown in the previous figures isreframed to show a rudimentary process of classification based on defining features

A decision tree can be useful as a simple rule-of-thumb approach to human decision making. It can also be a useful method of prioritizing information gathering. In the lower classification case, it is not necessary to measure anything other than petal length to make a classification decision in a third of the samples. Similar criteria priorities may exist in marketing products to individuals. For example, it may be mostvaluable to know gender, followed by age. We can use priorities to order fields in an online account profile, or questions in a survey, to target the most important data.

e-ISSN 2320 –7876 www.ijfans.org
Vol.11, Iss.9, Dec 2022

Trees are also perfect for understanding organizations. A family tree is an example of a visualization technique for an organizational hierarchy, where ancestors are placed at the root and children branch out from parent nodes. he work-life equivalent of a family tree is commonly called an organizational chart, or org chart. An org chart shows the structure of who reports to whom in a business, from CEO on down the chain of authority. Org charts provide information about corporate structure, as well as a frame work for understanding corporate performance

Theoretical Background for Proposed Mathematical Model of Graph Theory for Big Network for Big Data

This Chapter provides the theoretical background for proposed mathematical model of Graph Theory for Big network for Big Data. It covers topics like Graph Transformation, Algebraic Approach to Graph Transformation, Graph Databases, Visualization System, Web Searching, Internet Analysis, Data Set etc.

General Overview of Graph and Model Transformation

In this general introduction, we give a general overview of graph and model transformation and a short overview of the parts and chapters of the thesis. The main definitions in this thesis are the following: [36], [93]

- Graph transformation.
- The algebraic approach to graph transformation.
- The model transformation.
- The algebraic graph transformation support model transformation.

Graph Transformation

Graphs are important structures in mathematics, computer science and several other research and application areas. A graph consists of nodes, also called vertices; edges; and two functions assigning source and targe nodes to each edge. In fact, there are several variants of graphs, like labeled, typed, and attributed graphs, which will be considered in this book, because they are important for different kinds of applications. Prosperities of graphs, like shortest paths, are studied within graph theory, where in general the structure of the graph is

e-ISSN 2320 –7876 www.ijfans.org
Vol.11, Iss.9, Dec 2022

not changed. Graph transformation, in contrast, is a formal approach for structural modifications of graphs Vis the application of transformation rules. A graph rule, also called production $p = (L, R)$, consist of a left- hand side graph L, a right-hand side graph and a mechanism specifying how to replace by as shown schematically in Fig. 3.1 [42], [101].

e-ISSN 2320 –7876 www.ijfans.org
Vol.11, Iss.9, Dec 2022

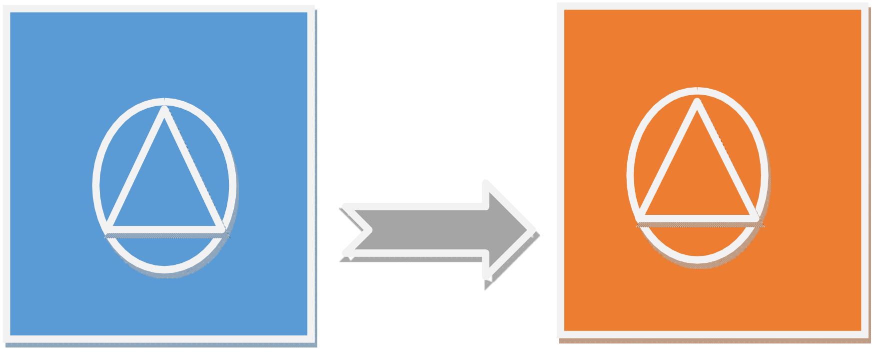

Fig. 3.1 Rule-based modification of graphs
$P = (L, R)$

The graph replacement mechanism is different in each of the following main graph transformation approaches presented in this chapter of Graph Grammars and Computing by Graph Transformation:

- Node Label Replacement Approach
- Hyper edge Replacement Approach
- Algebraic Approach
- Logical Approach
- Theory of 2-Structure
- Programmed Graph Replacement Approach

In all approaches, a graph transformation system consists of a set of rules; moreover, a graph transformation system together with a distinct start graph forms a graph grammar.

Conclusions

This research Entitled "Application of Graph Theory to Computer Science in Big Network for Big Data", is a novel and innovative idea of inter-disciplinary, application of Mathematical foundations of Computer Sciences, Graph Theoretic Mining Approach to Computer Science Big Networks for Big Data for Network Analysis regarding Security and Privacy concerns. Major contribution of thesis is formulation of a mathematical graph model using Graph

e-ISSN 2320 –7876 www.ijfans.org
Vol.11, Iss.9, Dec 2022

Mining and validated in on various compute science case studies and considerable satisfactory empirical results were obtained for security and privacy metrics. The present research work attempts to applying Graph Mining Mathematical Model for Big Data Network Analysis for technology transfer to extension of Big Data Social Media Analytics. The issues of research work are uniformly accommodated in five chapters. In each chapter, the needs and techniques that are required to achieve objective of research work are well discussed. They are summarized as follows. The First Chapter identifies fundamental tasks of Introduction to Application of Graph Theory to Computer Science for Big Networks for Big Data like Graph Theory, Graph Theory: A Pivotal Branch of Mathematics, Graph Theory Applications, Graph Theory and Computer Science, Big Data. The Four V's of Big Data, Big Data, Framework Technologies, The Hadoop Framework, Big Data Tools, Security and Privacy Issues of Big Data, Integration of Cloud Computing and Big Data, Research Issues of Big Data, Big Networks for Big Data, Data Mining, Graph Mining, putting it All Together: Graph Theoretic, Mining for Big Networks for Big Data, Analysis, Graphs Today, Graph for Every Problem, Relationships, Hierarchies, Research Motivation and Problem Statement, Organization of Thesis Second Chapter gives detailed Literature Review. The Literature Survey was carried out and analyzing information related to issues of research work is presented. Different approaches and ideas of various previous researchers and authors are dealt to motivate for a new idea and concepts that would enable for an innovation which lead to the proposed methodology Review of Literature on Application of Graph Theory to Computer Science for Big Networks for Big Data, Review of Literature on Graph Theory and Computer Science, Review of Literature on for Big Data, Research Motivation and Problem Statement and Basis to the Thesis etc.

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211

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