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A STUDY ON GRAPHS

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A Study on Graphs

Archana Kumari

MSc (Mathematics), M.Phil. NET Qualified, Village – Khera Chappra, Post Office – Subri, Distt. Karnal (Haryana),
Pin Code – 132001 – India

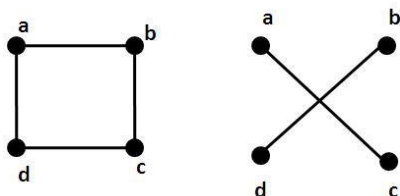
Abstract – A graph G consists of a nonempty set $V(G)$ of objects called vertices and a (possibly empty) set $E(G)$ of two element subsets of $V(G)$, called edges. The set $V(G)$ is called the vertex set of G and $E(G)$ its edge set. The number of vertices in a graph G is called its order, and the number of edges is its size. A graph of order p and size q is called a (p, q) -graph.

INTRODUCTION

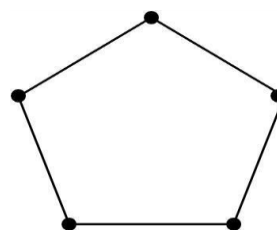
It has become a tradition to describe graphs by means of diagrams in which each element of the vertex set of the graph is represented by a dot and an edge $e = uv$ is represented by a curve joining the dots that represent the vertices u and v . A parameter that appears often when studying graphs is the degree of vertex. The degree of a vertex u of a graph G , denoted by $\deg u$, or simply by $\deg u$ or $d(u)$, if the graph G is clear from the context, is defined as $d(u) = |\{v/uv \in E(G)\}|$. A vertex v of a graph G is called even, if its degree is even and odd, if its degree is odd. Also, if $\deg v = 0$, v is called an isolated vertex, and if $\deg v = 1$, it is called an end vertex. Also, if $e = uv$ is an edge of a graph G such that either $\deg u = 1$ or $\deg v = 1$, then e is called a pendant edge of G .

Two graphs are said to be isomorphic if they have the same structure, and at the most, they differ in the way their vertices and edges are labeled, or in the way they are drawn.

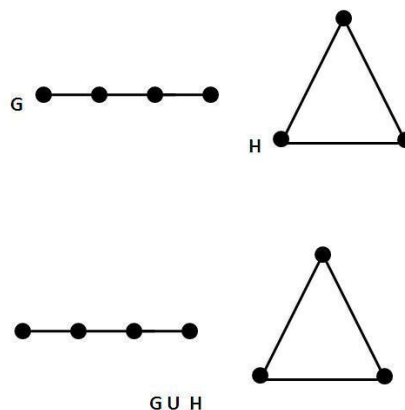
The complement \bar{G} of a graph G has $V(G)$ as its vertex set, but two vertices are adjacent in \bar{G} if and only if they are not adjacent in G . A graph and its complement are shown in Figure.



The graphs K_p are called totally disconnected, and are regular of degree 0. A self-complementary graph is one which is isomorphic to its complement. A self-complementary graph is shown in Figure.

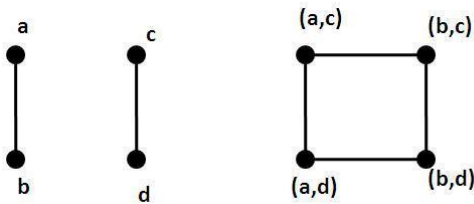


We also discuss here those operations on graphs that are used in this thesis. In all the definitions follows, we assume that, graphs G_1 and G_2 have disjoint vertex sets V_1 and V_2 and their edge sets as E_1 and E_2 respectively. The union of G_1 and G_2 , denoted as $G = G_1 \cup G_2$ has $V = V_1 \cup V_2$ and $E = E_1 \cup E_2$. Join of G_1 and G_2 , as defined by Zykov [31], denoted $G_1 + G_2$, the vertex set consists of $V = V_1 \cup V_2$ and the edge set, all edges obtained by joining V_1 with V_2 . In particular, $K_{m,n} = K_m + K_n$. These operations, namely union and join of two graphs G and H are illustrated in Figure 1.4 and 1.5 with $G = K_3$ and $H = P_4$.

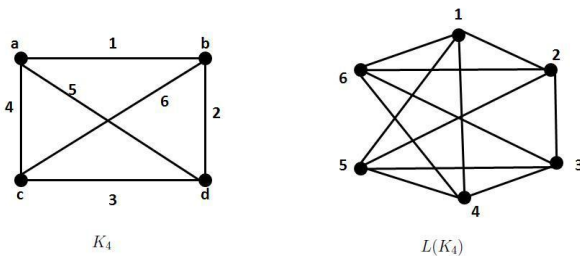


For any connected graph G , we write nG for the graph with n components, each isomorphic to G . Then every graph can be written in the form $\bigcup_{i=1}^n n_i G_i$ with G_i different from G_j for $i \neq j$. To define the cartesian product $G_1 \times G_2$, consider any two vertices

$u = (u_1, u_2)$ and $v = (v_1, v_2)$ in $V = V_1 \times V_2$. Then u and v are adjacent in $G_1 \times G_2$ whenever $u_1 = v_1$ and $u_2 v_2 \in E(G_2)$ or $u_2 = v_2$ and $u_1 v_1 \in E(G_1)$. The cartesian product of $G_1 = P_2$ and $G_2 = P_2$ is shown in Figure.



Let graph G has at least one edge. The line graph $L(G)$ of G , has $E(G)$ as its vertex set with two vertices of $L(G)$ are adjacent whenever the corresponding edges of G are adjacent. The line graph of K_4 is shown in Figure 1.11. We write $L_2(G) = L(L(G))$, and in general $L_n(G) = L(L_{n-1}(G))$.



The distance $d(u, v)$ between two vertices u and v in G is the minimum length of a path joining them if any; otherwise $d(u, v) = \infty$. A shortest u - v path is called a u - v geodesic. The diameter $d(G)$ of a connected graph G is the length of any longest geodesic.

REVIEW OF LITERATURE:

A classical subject of metric graph theory that are related to geometric questions are that of distance regular graphs which are intimately related with combinatorial designs and finite geometries. The study of low-distortion embeddings of graphs and finite metric spaces into l_2 or l_1 spaces with numerous applications in the design of approximation algorithms was initiated by Linial et.al.

In the mathematical field of graph theory, the hypercube Q_n is a regular graph with 2^n vertices, which corresponds to the subsets of a set with n elements. Two vertices labeled by subsets W and B are joined by an edge if and only if W can be obtained from B by adding or removing a single element.

Geometric representations of graphs have been much studied for the insight they provide into the graph algorithms, graph structure, and graph visualization. Linial et.al. Considered the following representation problem: for which unweighted undirected graphs can we assign integer coordinates in some d -dimensional

space \mathbb{Z}^d , such that the distance between two vertices in the graph is equal to the L_1 -distance between their coordinates? They (Linial et.al.) called the minimum possible dimension d of such an embedding (if one exists), the lattice dimension of the graph, and shown that the lattice dimension of any lattice-embeddable graph may be found in polynomial time. It is also shown that the lattice dimension of any tree is exactly $\log_2 l$, where l denotes the number of leaves of the tree.

Any l -length path can be viewed as a sub-graph of the hypercube $\{0, 1\}^l$ by mapping its vertices to the points where superscripting stands for repetition of coordinates. Similarly, finite portions of the integer lattice can be mapped isometrically to a hypercube $\{0, 1\}^d$, by applying the above embedding separately to each lattice coordinate. The graphs with finite lattice dimension are exactly the isometric hypercube sub-graphs, also known as partial cubes.

The partial cube representation of a graph is unique up to cube symmetries and, a polynomial time algorithm for finding such representations is known from the work of Djokovic. Partial cubes arise naturally as the state transition graphs of media, systems of states and state transitions studied by Falmagne et. al. that arise in political choice theory and that can also be used to represent many familiar geometric and combinatorial systems such as hyper-plane arrangements.

The integer lattice can be viewed as a cartesian product of paths; instead, one could consider products of other graphs. Thus, for instance, one could similarly define the tree dimension of a graph to be the minimum k such that the graph has an isometric embedding into a product of k trees. The graphs with finite tree dimension are again just the partial cubes. Chepoi et. al. showed that, certain graph families have bounded tree dimension, and used the corresponding product representations as a data structure to answer distance queries in these graphs. Recognizing graphs with tree dimension k is polynomial for $k = 2$, but NP-complete for any $k > 2$.

Let (V_n, d) be a distance space where d is rational valued. Then, (V_n, d) is l_1 -embeddable if and only if (V_n, d) is hypercube embeddable for some scalar. Let d be a distance on V_n that is embeddable and takes rational values. Every integer for which (V_n, d) is hypercube embeddable is called a scale of (V_n, d) . They also called d is hypercube embeddable with scale. The smallest such integer is called the minimum scale of (V_n, d) and is denoted by d . Deza et.al also established the following Lemma.

There exists an integer such that d is hypercube embeddable for every embeddable distance d on V_n that is an integer valued. Deza et.al also initiated to study the graphs whose path metric admits some properties of the above mentioned embedding and accordingly they defined graphs. A graph G is called a graph, if its path metric d_G is isometrically

embeddable. Similarly, a graph G is called a hypercube embeddable graph, if its path metric d_G is isometrically hypercube-embeddable. Equivalently, a graph G is said to be hypercube embeddable if its vertices can be labelled with the Hamming distance between their labels.

RESEARCH METHODOLOGY:

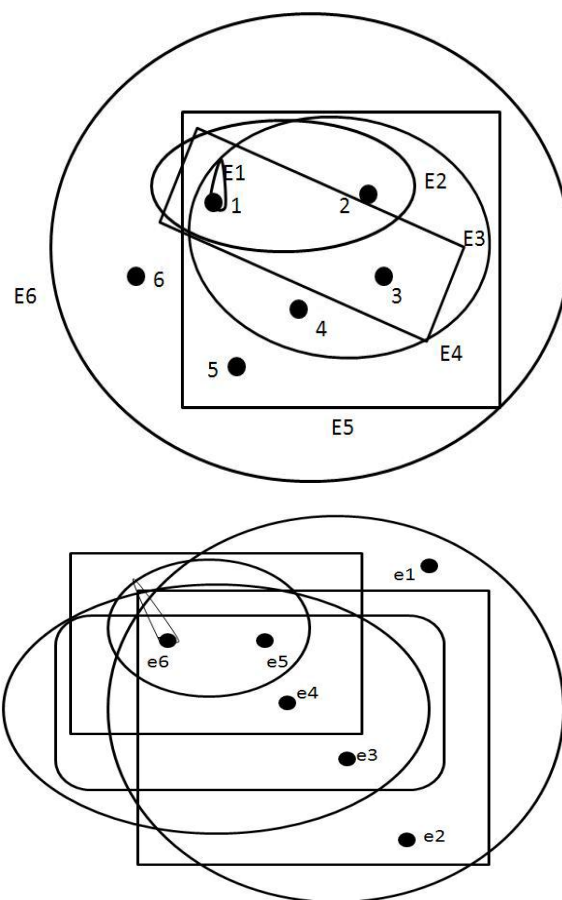
A graph $G = (V, E)$ is called a bitopological graph if there exist a set X and a set-indexer f on G such that both $f(V)$ and $f(E)$ are topologies on X . The corresponding set-indexer is called a bitopological set-indexer of G . We prove the existence of bitopological set-indexer. We give a characterization of bitopological complete graphs. We define equi-bitopological graphs and establish certain results on equi-bitopological graphs. We identify certain classes of graphs, which are bitopological and define bitopological index (G) of a finite graph G as the minimum cardinality of the underlying set X .

Given a graph $G = (V, E)$, we can relate it to different topological structures. In 1967, J. W. Evans et.al [8] conceived this idea and he proved that there is a one to one correspondence between the set of all topologies on a set X with n points and the set of all transitive digraphs with n points. He established his results as follows. Let V be a finite set and T be a topology on V . The transitive digraph corresponding to this topology is got by drawing a line from u to v , if and only if, u is in every open set containing v . Conversely let D be a transitive digraph on V ; the family $B = \{Q(a) : a \in V\}$ forms a base for a topology on V , where $Q(a) = \{a\} \cup \{b \in V : (b, a) \in E(D)\}$. In 1968 T.N. Bhargava and T.J. Ahlborn analysed the topological spaces associated with digraphs. According to them a subset A of $V(D)$ is open if and only if for every pair of points $i, j \in V$ with j in A and i not in A , (i, j) is not a line in D . Sampathkumar extended this results to the case in which the point set is infinite. Sampathkumar et.al also investigated the topological spaces associated with signed graphs and semigraphs. Let $S = (V, E)$ be a signed graph. A subset A of V is an open set in the positive E -topology on S denoted by S^+ if and only if $u \in A, uv \in E^+(S)$ implies that $v \in A$. Similarly he defined negative E -topology (S^-) . He defined the topology V on the vertex set $V(D)$ of a disemigraph $D = (V, E)$ as follows: A subset S of $V(D)$ is open whenever $u \in S$ and $v \in V(D)$ such that vu is a partial arc, then $v \in S$.

Hypergraph theory is something different and much more generalized concept of graph theory. Given a set V of vertices, an edge of a simple graph on V is a set of two vertices, while an edge of a hypergraph on V is any subset of V . The theory of hypergraphs popularized and enriched by many contributions of Berge is the extension of theorems about graphs to hypergraphs. The problem is to find a suitable

formulation of the theorems for hypergraphs in such a way that they contain the graph as a special case.

Chromatic index of the hypergraph H of dcs-graph $K_{1,7}$ is eight, equal to the degree of H . Thus, we strongly believe that the hypergraphs of dcs-graphs are graphs which satisfy the coloured edge property. In general, a hypergraph and its dual hypergraph need not be isomorphic. But it happens in the case of 1-uniform digraphs. It is interesting to note that, if (G, f) is a 1-uniform di-graph then, the hypergraph $H_f G$ and the dual hypergraph of $H_f G$ are isomorphic. Figure give the hypergraph corresponding to 1-uniform path P_6 and Figure depicts its dual graph. Note that the hypergraphs in Figure



CONCLUSION:

The theory of isometric set-labeling are rich in theory, with many applications. The main motivation to study isometric set-labeling is due to the problem in communication theory posed by Pierce in 1972. In a telephone network one wishes to be able to establish a connection between two terminals A and B without B knowing that a message is on its way. The idea is to let the message be proceeded by some 'address' of B , permitting to decide at each node of the network in which direction the message should proceed. The message will proceed to the next node if its hamming distance to the destination node B is shorter or, at a

constant proportionality distance or, at various fixed constants of proportionality. The most natural way of devising such a scheme is by labeling the nodes by strings of subsets of a set X , which amounts to try to embed the graph in a dcsI-graph.

Interesting problems and conjectures are identified in both the dcsIgraphs, bitopological graphs and hypergraph representation of dcsIgraphs. They are already pointed out in the respective chapters. However, we list below some of the most important problems which are open for further research and investigation.

Problem 1. Characterize a dispersible dcsI-graph.

Problem 2. Consider any structure-activity relationship R of a molecular graph that has been identified to be well correlated with the Wiener index. Is it possible to achieve such a correlation using MWeiner index for a low cardinality dcsI-sets X as possible?

Problem 3. For any dcsI-graph G , the dispersivity of (G) of G is the least cardinality of a ground set X , such that G admits a dispersive dcsI. Also, find K_n .

Problem 4. Find the necessary condition for a graph to be I_1 -embeddable, k -uniform dcsI-graph.

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