Application of graph in data structure pdf

Graph Theory is used in vast area of science and technologies. Some of them are given below: 1. Computer Science In computer science graph theory is used for the study of algorithms like: Dijkstra's Algorithm Prims's Algorithm Kruskal's Algorithm Graphs are used to define the flow of computation. Graphs are used to represent networks of communication. Graphs are used to represent data organization. Graph transformation systems work on rule-based in-memory manipulation of graphs. Graph databases ensure transaction-safe, persistent storing and querying of graph structured data. Graph theory is used to find shortest path in road or a network. In Google Maps, various locations are represented as vertices or nodes and the roads are represented as edges and graph theory is used to find the shortest path between two nodes. 2. Electrical Engineering In Electrical Engineering, graph theory is used in designing of circuit connections. These circuit connections are named as topologies. Some topologies are series, bridge, star and parallel topologies. 3. Linguistics In linguistics, graphs are mostly used for parsing of a language tree and grammar of a language tree. Semantics networks are used within lexical semantics, especially as applied to computers, modeling word meaning is easier when a given word is understood in terms of related words. Methods in phonology (e.g. theory of optimality, which uses lattice graphs) and morphology (e.g. morphology of finite - state, using finite-state transducers) are common in the analysis of language as a graph. 4. Physics and Chemistry In physics and chemistry, graph theory is used to study molecules. The 3D structure of complicated simulated atomic structures can be studied quantitatively by gathering statistics on graph-theoretic properties related to the topology of the atoms. Statistical physics also uses graphs. In this field graphs can represent local connections between interacting parts of a system, as well as the dynamics of a physical process on such systems. Graphs are also used to express the micro-scale channels of porous media, in which the vertices represent the pores and the edges represent the smaller channels connecting the pores. Graph is also helpful in constructing the molecular structure as well as lattice of the molecule. It also helps us to show the bond relation in between atoms and molecules, also help in comparing structure of one molecule to other. 5. Computer Network In computer network, the relationships among interconnected computers within the network, follow the principles of graph theory. Graph theory is also used in network security. We can use the vertex coloring algorithm to find a proper coloring of the map with four colors. Vertex coloring algorithm may be used for assigning at most four different frequencies for any GSM (Grouped Special Mobile) mobile phone networks. 6. Social Sciences Graph theory is also used in sociology. For example, to explore rumor spreading, or to measure actors' prestige notably through the use of social network analysis software. Acquaintanceship and friendship graphs describe whether people know each other or not. In influence graphs model, certain people can influence the behavior of others. In collaboration graphs model to check whether two people work together in a particular way, such as acting in a movie together. 7. Biology Nodes in biological networks represent bimolecular such as genes, proteins or metabolites, and edges connecting these nodes indicate functional, physical or chemical interactions between the corresponding bimolecular. Graph theory is used in transcriptional regulation networks. It is also used in Metabolic networks. In PPI (Protein - Protein interaction) networks graph theory is also useful. Characterizing drug - drug target relationships. 8. Mathematics In mathematics, operational research is the important field. Graph theory provides many useful applications in operational research. Like: Minimum cost path. A scheduling problem. 9. General Graphs are used to represent the routes between the cities. With the help of tree that is a type of graph, we can create hierarchical ordered information such as family tree. Next TopicBasic Properties For Videos Join Our Youtube Channel: Join Now Send your Feedback to In this article, we learned the basics of graphs and how to implement them. Let us recollect the important points.A graph is a non-linear data structure that can be defined as a set of V vertices and E edges where the edges connect two vertices in a directed or undirected fashion.Graphs can be used in problems where there are multiple ways to travel from vertex A to vertex B.A Very Popular Example is the Travelling Salesman Problem (TSP)Consider a set of cities and the distances between them. We need to find the shortest possible route such that a salesman starts from one city and comes back to the same city without visiting any city twice.We can use graphs to visualize this problem as a city is a vertex and the distance between them is an edge essentially.We can see a variation of this problem being used in Google Maps.Assume you have to go from city A to E.There are 3 routes to do so as can be seen from the diagram below.Route 1 goes through two cities B and C Route 2 goes through only one city D Route 3 is an expressway and directly goes to ENow this problem can be modelled as a graph. We can visualize the cities as vertices and the roads as edges. Each edge has two attributes associated: distance and time. Hence we need to account for both in the cost calculation, as Google maps try to optimize the time as well as the distance.Since the cost is directly proportional to the time and distance, the cost of travel is time * distance.Thus cost of route 1 = (1 + 1 + 0.5) * (100 + 100 + 50) = 625 cost of route 2 = (2 + 1) * (100 + 100) = 600 cost of route 3 = 2 * 300 = 600Thus Google Maps will suggest us either route 2 or route 3.The above logic in data structures and algorithms is called a Breadth-First Search. By visualizing such traversal problems as a graph data structure we can run algorithms like BFS to solve complicated problems.Have you ever wondered how Facebook knows how a person is your mutual friend, or how LinkedIn know if some connection is a 2nd or 3rd connection?Facebook and LinkedIn models their users as a graph where every vertex is a user profile and the edge between two people is the fact that they are friends with each other or follow each other.Consider two people A and B on Facebook who have several friends. We can build a graph of their relationships.Now if Facebook finds all the immediate friends of A, by going through all the immediately adjacent vertices of A, we shall get the set {E,C,D,F}Similarly, the set of adjacent vertices of B would be {C,D,G}If we take an intersection of the above two sets, we shall get the set of mutual friends viz. {C,D}LinkedIn takes it one level higher by telling you how much distance one user has from the other. Assume a graph of users as follows.We can see that users A and B are connected to each other in two ways.In graphs, we call two vertices connected if there exists a path between the two.LinkedIn computes all the possible paths between two users and reports the length of the shortest path as the degree of connection between two users.Google Uses Graphs to Build a Knowledge BaseThere are millions of articles on the internet, be it about famous people, food, animals, cities, or history. Every article is centred around an object, the object could be a person, an animal, some food item or a country. We can visualize these objects as a vertex in a graph. The relationship between them can be thought of as an edge in the graph.For example, Albert Einstein was born in Germany. This fact can be broken down into two vertices, Einstein and Germany. Einstein being born in Germany is a relationship, essentially an edge between Einstein and Germany.Google crawls through almost all public internet links and tries to build a knowledge graph of all the information out there on the Internet.Google then uses this graph to show relevant information when a user searches for a keyword on Google search.For example, this is what you see when you search Einstein's name. There is a plethora of information that Google has understood is connected to Einstein due to their knowledge graphs! Graphs in data structures are non-linear data structures made up of a finite number of nodes or vertices and the edges that connect them. Graphs in data structures are used to address real-world problems in which it represents the problem area as a network like telephone networks, circuit networks, and social networks. For example, it can represent a single user as nodes or vertices in a telephone network, while the link between them via telephone represents edges. What Are Graphs in Data Structure? A graph is a non-linear kind of data structure made up of nodes or vertices and edges. The edges connect any two nodes in the graph, and the nodes are also known as vertices. This graph has a set of vertices V= { 1,2,3,4,5} and a set of edges E= { (1,2),(1,3),(2,3),(2,4),(2,5),(3,5),(4,50 }. Now that you've learned about the definition of graphs in data structures, you will learn about their various types. Types of Graphs in Data Structures There are different types of graphs in data structures, each of which is detailed below. 1. Finite Graph The graph G=(V, E) is called a finite graph if the number of vertices and edges in the graph is limited in number 2. Infinite Graph The graph G=(V, E) is called a finite graph if the number of vertices and edges in the graph is interminable. 3. Trivial Graph A graph G= (V, E) is trivial if it contains only a single vertex and no edges. 4. Simple Graph If each pair of nodes or vertices in a graph G=(V, E) has only one edge, it is a simple graph. As a result, there is just one edge linking two vertices, depicting one-to-one interactions between two elements. 5. Multi Graph If there are numerous edges between a pair of vertices in a graph G= (V, E), the graph is referred to as a multigraph. There are no self-loops in a Multigraph. 6. Null Graph It's a reworked version of a trivial graph. If several vertices but no edges connect them, a graph G= (V, E) is a null graph. 7. Complete Graph If a graph G= (V, E) is also a simple graph, it is complete. Using the edges, with n number of vertices must be connected. It's also known as a full graph because each vertex's degree must be n-1. 8. Pseudo Graph If a graph G= (V, E) contains a self-loop besides other edges, it is a pseudograph. 9. Regular Graph If a graph G= (V, E) is a simple graph with the same degree at each vertex, it is a regular graph. As a result, every whole graph is a regular graph. 10. Weighted Graph A graph G= (V, E) is called a labeled or weighted graph because each edge has a value or weight representing the cost of traversing that edge. 11. Directed Graph A directed graph also referred to as a digraph, is a set of nodes connected by edges, each with a direction. 12. Undirected Graph An undirected graph comprises a set of nodes and links connecting them. The order of the two connected vertices is irrelevant and has no direction. You can form an undirected graph with a finite number of vertices and edges. 13. Connected Graph If there is a path between one vertex of a graph data structure and any other vertex, the graph is connected. 14. Disconnected Graph When there is no edge linking the vertices, you refer to the null graph as a disconnected graph. 15. Cyclic Graph If a graph contains at least one graph cycle, it is considered to be cyclic. 16. Acyclic Graph When there are no cycles in a graph, it is called an acyclic graph. 17. Directed Acyclic Graph It's also known as a directed acyclic graph (DAG), and it's a graph with directed edges but no cycle. It represents the edges using an ordered pair of vertices since it directs the vertices and stores some data. 18. Subgraph The vertices and edges of a graph that are subsets of another graph are known as a subgraph. After you learn about the many types of graphs in graphs in data structures, you will move on to graph terminologies. Terminologies of Graphs in Data Structures Following are the basic terminologies of graphs in data structures: An edge is one of the two primary units used to form graphs. Each edge has two ends, which are vertices to which it is attached. If two vertices are endpoints of the same edge, they are adjacent. A vertex's outgoing edges are directed edges that point to the origin. A vertex's incoming edges are directed edges that point to the vertex's destination. The total number of edges occurring to a vertex in a graph is its degree. The out-degree of a vertex in a directed graph is the total number of outgoing edges, whereas the in-degree is the total number of incoming edges. A vertex with an in-degree of zero is referred to as a source vertex, while one with an out-degree of zero is known as sink vertex. An isolated vertex is a zero-degree vertex that is not an edge's endpoint. A path is a set of alternating vertices and edges, with each vertex connected by an edge. The path that starts and finishes at the same vertex is known as a cycle. A path with unique vertices is called a simple path. For each pair of vertices x, y, a graph is strongly connected if it contains a directed path from x to y and a directed path from y to x. A directed graph is weakly connected if all of its directed edges are replaced with undirected edges, resulting in a connected graph. A weakly linked graph's vertices have at least one out-degree or in-degree. A tree is a connected forest. The primary form of the tree is called a rooted tree, which is a free tree. A spanning subgraph that is also a tree is known as a spanning tree. A connected component is the unconnected graph's most connected subgraph. A bridge, which is an edge of removal, would sever the graph. Forest is a graph without a cycle. Following that, you will look at the graph representation in this data structures tutorial. Representation of Graphs in Data Structures Graphs in data structures are used to represent the relationships between objects. Every graph consists of a set of points known as vertices or nodes connected by lines known as edges. The vertices in a network represent entities. The most frequent graph representations are the two that follow: Adjacency matrix Adjacency list You'll look at these two representations of graphs in data structures in more detail: Adjacency Matrix A sequential representation is an adjacency matrix. It's used to show which nodes are next to one another. I.e., is there any connection between nodes in a graph? You create an MXM matrix G for this representation. If an edge exists between vertex a and vertex b, the corresponding element of G, gi,j = 1, otherwise gi,j = 0. If there is a weighted graph, you can record the edge's weight instead of 1s and 0s. Undirected Graph Representation Directed Graph Representation Weighted Undirected Graph Representation Weight or cost is indicated at the graph's edge, a weighted graph representing these values in the matrix. Adjacency List A linked representation is an adjacency list. You keep a list of neighbors for each vertex in the graph in this representation. It means that each vertex in the graph has a list of its neighboring vertices. You have an arra of vertices indexed by the vertex number, and the corresponding array member for each vertex x points to a singly linked list of x's neighbors. Weighted Undirected Graph Representation Using Linked-List Weighted Undirected Graph Representation Using an Array You will now see which all operations are conducted in graphs data structure after understanding the representation of graphs in the data structure. Also Read: Linked List in A Data Structure Operations on Graphs in Data Structures The operations you perform on the graphs in data structures are listed below: Creating graphs Insert vertex Delete vertex Insert edge Delete edge You will go over each operation in detail one by one: Creating Graphs There are two techniques to make a graph: 1. Adjacency Matrix The adjacency matrix of a simple labeled graph, also known as the connection matrix, is a matrix with rows and columns labeled by graph vertices and a 1 or 0 in position depending on whether they are adjacent or not. 2. Adjacency List A finite graph is represented by an adjacency list, which is a collection of unordered lists. Each unordered list describes the set of neighbors of a particular vertex in the graph within an adjacency list. Insert Vertex When you add a vertex that after introducing one or more vertices or nodes, the graph's size grows by one, increasing the matrix's size by one at the row and column levels. Delete Vertex Deleting a vertex refers to removing a specific node or vertex from a graph that has been saved. If a removed node appears in the graph, the matrix returns that node. If a deleted node does not appear in the graph, the matrix returns the node not available. Insert Edge Connecting two provided vertices can be used to add an edge to a graph. Delete Edge The connection between the vertices or nodes can be removed to delete an edge. The types of graph traversal algorithms will be discussed next in the graphs in this data structures tutorial. Graph Traversal Algorithm The process of visiting or updating each vertex in a graph is known as graph traversal. The sequence in which they visit the vertices is used to classify such traversals. Graph traversal is a subset of tree traversal. There are two techniques to implement a graph traversal algorithm: Breadth-first search Depth-first search Breadth-First Search or BFS BFS is a search technique for finding a node in a graph data structure that meets a set of criteria. It begins at the root of the graph and investigates all nodes at the current depth level before moving on to nodes at the next depth level. To maintain track of the child nodes that have been encountered but not yet inspected, more memory, generally you require a queue. Algorithm of breadth-first search Step 1: Consider the graph you want to navigate. Step 2: Select any vertex in your graph, say v1, from which you want to traverse the graph. Step 3: Examine any two data structures for traversing the graph. Visited array (size of the graph) Queue data structure Step 4: Starting from the vertex, you will add to the visited array, and afterward, you will v1's adjacent vertices to the queue data structure. Step 5: Now, using the FIFO concept, you must remove the element from the queue, put it into the visited array, and then return to the queue to add the adjacent vertices of the removed element. Step 6: Repeat step 5 until the queue is not empty and no vertex is left to be visited. Depth-First Search or DFS DFS is a search technique for finding a node in a graph data structure that meets a set of criteria. The depth-first search (DFS) algorithm traverses or explores data structures such as trees and graphs. The DFS algorithm begins at the root node and examines each branch as far as feasible before backtracking. To maintain track of the child nodes that have been encountered but not yet inspected, more memory, generally a stack, is required. Algorithm of depth-first search Step 1: Consider the graph you want to navigate. Step 2: Select any vertex in our graph, say v1, from which you want to begin traversing the graph. Step 3: Examine any two data structures for traversing the graph. Visited array (size of the graph) Stack data structure Step 4: Insert v1 into the array's first block and push all the adjacent nodes or vertices of vertex v1 into the stack. Step 5: Now, using the FIFO principle, pop the topmost element and put it into the visited array, pushing all of the popped element's nearby nodes into it. Step 6: If the topmost element of the stack is already present in the array, discard it instead of inserting it into the visited array. Step 7: Repeat step 6 until the stack data structure isn't empty. You will now look at applications of graph data structures after understanding the graph traversal algorithm in this tutorial. Application of Graphs in Data Structures Following are some applications of graphs in data structures: Graphs are used in computer science to depict the flow of computation. Users on Facebook are referred to as vertices, and if they are friends, there is an edge connecting them. The Friend Suggestion system on Facebook is based on graph theory. You come across the Resource Allocation Graph in the Operating System, where each process and resource are regarded vertically. Edges are drawn from resources to assigned functions or from the requesting process to the desired resource. A stalemate will develop if this results in the establishment of a cycle. Web pages are referred to as vertices on the World Wide Web. Suppose there is a link from page A to page B that can represent an edge. This application is an illustration of a directed graph. Graph transformation systems manipulate graphs in memory using rules. Graph databases store and query graph-structured data in a transaction-safe, permanent manner. Finally, in this tutorial, you'll look at the code for the graphs in data structures Code Implementation of Graphs in Data Structures #include #include #include #define V 6 // Define the maximum number of vertices in the graph struct graph // declaring graph data structure { struct Node* point[V]; // An array of pointers to Node to represent an adjacency list }; struct Node // declaring node { int destination; struct Node* next; }; struct link // declaring edge { int source, destination; }; struct graph* make_Graph(struct link edges[], int x) // function to create graph { int i; struct graph* graph = (struct graph*)malloc(sizeof(struct graph)); // defining graph for (i = 0; i < V; i++) { graph->point[i] = NULL; } for (i = 0; i < x; i++) { int source = edges[i].source; int destination = edges[i].destination; struct Node* Node1 = (struct Node*)malloc(sizeof(struct Node)); Node1->destination = destination; Node1->next = graph->point[source]; graph->point[source] = Node1; } return graph; } void displayGraph(struct graph* graph) // function to view garph { int i; for (i = 0; i < V; i++) { struct Node* ptr = graph->point[i]; while (ptr != NULL) { printf("(%d —> %d)\t", i, ptr->destination); ptr = ptr->next; } printf(""); } } int main(void) { struct link edges[] = { { 0, 1 }, { 1, 3 }, { 3, 0 }, { 3, 4 }, { 4, 5 }, { 5, 6 } }; int n = sizeof(edges)/sizeof(edges[0]); struct graph *graph = make_Graph(edges, n); displayGraph(graph); return 0; } Output (0 ù> 1) (1 ù> 3) (3 ù> 4) (3 ù> 0) (4 ù> 5) (5 ù> 6) -------------------------------- Process exited after 0.06697 seconds with return value 0 Press any key to continue . . . Master front-end and back-end technologies and advanced aspects in our Post Graduate Program in Full Stack Web Development. Unleash your career as an expert full stack developer. Get in touch with us NOW! Next Step You learned what a graph data structure is and the many types of graph data structures in this "graphs in data structures" tutorial. Following that, you learned about the graph traversal method, which includes the breadth-first and depth-first search algorithms, as well as several graph data structure applications. "Breadth-first search or BFS "will be your next topic, where you will learn about the breadth-first search algorithm and how to traverse tree and graph data structure using BFS. If you want to learn more about data structures and programming languages, check out simplilearn's Full Stack Development Post Graduate Program might just be what you need. The bootcamp is offered in collaboration with Caltech CTME and will provide you with the work-ready software development skills, industry credentials and global recognition you need to succeed now. If you have any doubts regarding the "graphs in data structures "article, please feel free to ask in the comment section below. We will be happy to resolve your problems as soon as possible. Until then, stay tuned with Simplilearn's channel and keep learning.

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