FEDERAL STATE AUTONOMOUS EDUCATIONAL INSTITUTION
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Report

on the practical task No. 5

Algorithms on graphs. Introduction to graphs and basic algorithms on graphs

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Goal

The use of different representations of graphs and basic algorithms on graphs (Depth-first search and Breadth-first search)

Formulation of the problem

Generate a random adjacency matrix and make different visualizations about it, apply depth first search on it, describe the data structures and algorithms.

Brief theoretical part

Depth first Search (DFS) or Depth first traversal is a recursive algorithm for searching all the vertices of a graph or tree data structure. Traversal means visiting all the nodes of a graph. The purpose of the algorithm is to mark each vertex as visited while avoiding cycles. A standard DFS implementation puts each vertex of the graph into one of two categories:

- Visited
- Not Visited

Breadth first search (BFS) is a recursive algorithm for searching all the vertices of a graph or tree data structure, in the same way as DFS each vertex can be visited or not visited. It starts at the tree root and explores all nodes at the present depth prior to moving on to the nodes at the next depth level. Extra memory, usually a queue, is needed to keep track of the child nodes that were encountered but not yet explored.

Results

Matrix

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
4	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
5	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0

In the adjacency matrix representation, a graph is represented in the form of a two-dimensional array. The size of the array is V x V, where V is the set of vertices.This representation makes use of VxV matrix, so space required in worst case is O(|V|2).

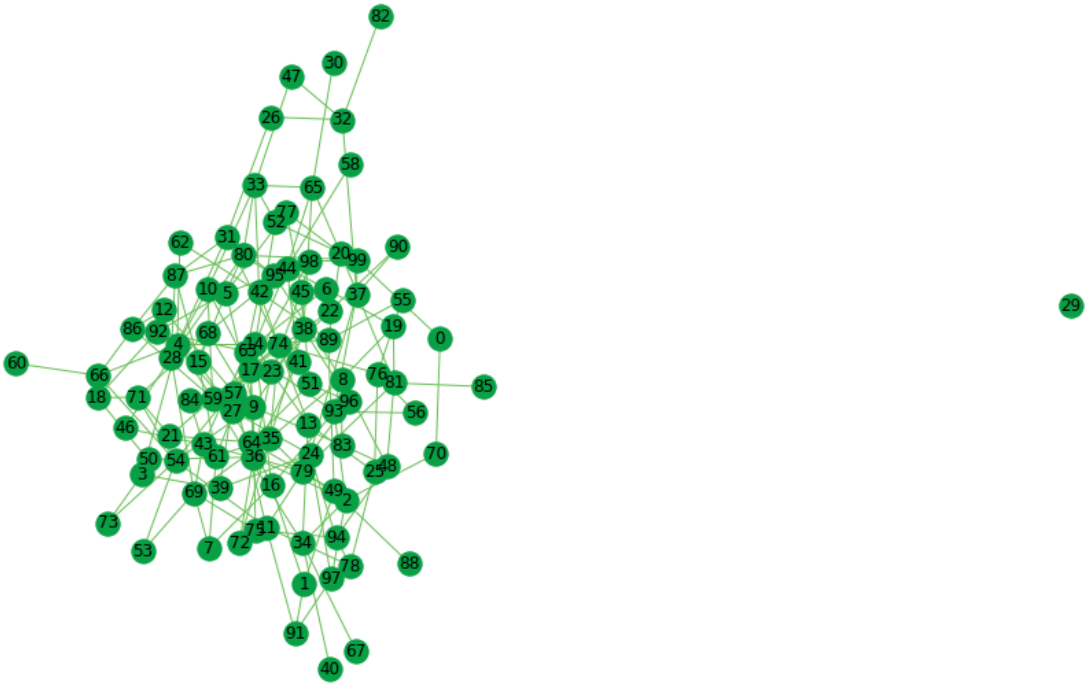
Adjacency list

0 70 99
1 16 49 91
2 34 36 70 79 93 97
3 4 39 73
4 14 27 31 59 62 66 92
5 9 15 77 80 92 95
6 19 44 45 63
7 16 61 69

8 19 35 48 83 95
9 17 38 54 68 75 83
10 17 28 33 59
11 54 57 78 79 91
12 57 86
13 23 25 34 42
14 16 23 27 52 89

In this representation, a graph is represented as an array of linked list. The index of the array represents a vertex and each element in its linked list represents the vertices that form an edge with the vertex. for every vertex we store its neighbours. In the worst case, if a graph is connected O(V) is required for a vertex and O(E) is required for storing neighbours corresponding to every vertex .Thus, overall space complexity is
O(|V|+|E|).

Visualization



total connected component: 2
connected component: [[0, 70, 2, 34, 13, 23, 14, 4, 3, 39, 24, 27, 37, 32, 26, 31, 74, 17, 9, 5, 15, 61, 7, 16, 1, 49, 64, 21, 59, 10, 28, 46, 43, 63, 6, 19, 8, 35, 38, 45, 51, 96, 77, 20, 52, 33, 42, 62, 89, 55, 76, 25, 48, 81, 79, 11, 54, 53, 69, 75, 94, 78, 66, 18, 50, 36, 41, 44, 57, 12, 86, 87, 80, 95, 99, 98, 58, 65, 30, 68, 71, 72, 92, 60, 73, 91, 97, 85, 83, 56, 93, 47, 84, 88, 22, 90, 82, 40, 67], [29]]

Shortest path

[4, 3, 39, 57, 44, 58]

Data Structures [2]

Array: Is a structure of fixed-size, which can hold items of the same data type. It can be an array of integers, an array of floating-point numbers, an array of strings or even an array of arrays (such as 2-dimensional arrays).

List: is a sequential structure that consists of a sequence of items in linear order which are linked to each other. Hence, you have to access data sequentially and random access is not possible. Linked lists provide a simple and flexible representation of dynamic sets.

Graph: A graph consists of a finite set of vertices or nodes and a set of edges connecting these vertices. The order of a graph is the number of vertices in the graph. The size of a graph is the number of edges in the graph. Two nodes are said to be adjacent if they are connected to each other by the same edge.

Design techniques

Loop: A loop in a computer program is an instruction that repeats until a specified condition is reached. In a loop structure, the loop asks a question. If the answer requires action, it is executed. The same question is asked again and again until no further action is required. Each time the question is asked is called an iteration [3].

Inheritance: is the mechanism of basing an object or class upon another object (prototype-based inheritance) or class (class-based inheritance), retaining similar implementation

Conclusions

- Visual representation allows humans to have an overview of the data and to understand the information based on the data
- The idea behind of BFS and DFS is avoid cycles in order to maximise performance in the working with graphs
- BFS is able to find a solution if it exists.

Bibliography

[1] Kochenderfer, Algorithms for optimization, 2019
[2] 8 Common Data Structures every Programmer must know, https://towardsdatascience.com/, 2021
[3]https://www.thoughtco.com/definition-of-loop-958105#:~:text=A%20loop%20in%20a%20computer,no%20further%20action%20is%20required.