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Path Finding Visualizer Application for Shortest Path Algorithm

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***Abstract*—Visualization is an efficient way of learning any concept faster than conventional methods. Modern technology allows creating e-Learning tools that also helps in improving computer science education very much. The goal of this project is to create a web based e-Learning tool, 'PathFinding Visualizer', which can be used to visualize shortest path algorithms. The conceptual application of the project is illustrated by implementation of algorithms like Dijkstra's , A* and DFS. This project aims to complete all these tasks with some knowledge of HTML, CSS, JavaScript and React Framework. The end product is a web application so that any user can easily see and learn the working of the algorithms. User-friendliness of the project provides user with easy instructions on how to operate it. The initial results of using the application show promises of the benefits of this e-Learning tool towards students getting a good understanding of shortest paths algorithms.**

Keywords—Visualization, Dijkstra's, A*, DFS, JavaScript, e-Learning tool, shortest path algorithms.

I. INTRODUCTION

At present, e-learning is being promoted at a very high rate among learners in different areas. Modern technologies allows the development of visualization tools for topics like different algorithms of graph theory and their explanation. The implementation of e-learning tools like this is one of the most important requirement for applying e-learning system successfully. Learning through visualization has been found helpful in enhancing learning capabilities. It adds more autonomy to the learning process for an individual person. By providing a visual representation of how the algorithms looks for destination node, the application aim at making it more understandable. Good algorithm visualization tools brings the algorithms to life by displaying the traversal of nodes by animating the transitions from one node to another.

One of the widely used application of graph theory is determination of shortest path in many practical application like maps,road networks and robot navigation. We use Dijkstra's algorithm to demonstrate the working of the tool because it also works for a weighted graph. Hence, it takes longer time to run compared to BFS. This algorithm guarantees the shortest path possible. Also, using online learning methods instead of face to face lectures has the power to improve learning with regards to better performance of students, satisfaction of student, and a higher flexibility in learning for the students.

Benefits of e-learning tools:

- It accommodates everyone's need.
- It is scalable and consistent.
- It's more effective than traditional ways.
- Offers better retention.
- Provides most up to date content.

The described e-learning tool allows the teachers, students and other aspirants to interact with algorithm, work in active way, and to visualize execution of shortest path algorithms.

II. DIJKSTRA SHORTEST PATH ALGORITHM

Dijkstra's algorithm is a single source shortest path first algorithm. It is useful in finding the shortest path of reaching from source to destination like between two points on a grid, which may represent, for example,robotic movements, road networks, maps, etc. It was developed by Edsger W. Dijkstra in 1956.

The algorithm has many variants. In early stages algorithm was made to find the shortest path between source and destination nodes, but at present the current variant of the algorithm simply takes a single node as source and treat every other node as destination and provides shortest paths from the source to all entered destinations in the grid in order to produce a shortest path tree. It also favors lower cost paths.

Dijkstra's algorithm uses data structures to store the nodes sorted by distance from source, primarily, min-priority queue was used but an array can also be used. It is one of the fastest shortest path first algorithm for situations where there is only one source to find shortest path for and arbitrary directed graphs having non-negative and unbounded weights. Algorithm works for undirected graph as well.

Example: Consider a situation where a person decides to go from one place to another through the shortest route possible and that he has information about which roads are heavily busy and expect high traffic issue and are very difficult to use. In an another such as Dijkstra's, this would mean that the edge of the graph is heavily weighted(the algorithm will try to avoid those routes that are heavily weighted). If the person makes use of GPS to look for directions, it has a high probability that they use Dijkstra's algorithm or any other pathfinding algorithm.

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A. Working of Dijkstra's algorithm:

The node from where we start is called Initial Node, the algorithm assigns initial distance values to all other nodes and keeps updating them step by step.

- At first it marks all nodes as unvisited and puts them in a set.
- Assign tentative distance values to intial node as zero and all others as infinity. Set current node to be seen as initial node.
- For initial node, tentative distance of the unvisited neighbour nodes and compare the newly found value to initially assigned value and replace with the one that it is the smaller one.
- When all unvisited nodes for current node are considered, we set the current node on the grid as a visited node and pull it out of the set of unvisited nodes.
- If the destination nodes is found and marked visited(while looking for a route between two specific points) or the situation where the smallest tentative distance among the source and all destinations in unvisited set becomes infinity(something like this is encountered when there is no relationship between source node and destination nodes in unvisited set), stop. Otherwise we select the unvisited node having smallest tentative distance and this node is seen as current node and then continue with step 3.

B. Applications of Dijkstra's Algorithm:

- Algorithm has been found to be proven useful in cases where there is only one source and multiple destinations. Dijkstra's algorithm is helpful in creating road network and reduce the cost of laying roads.
- Applicable in Network routing protocols, For e.g. in Intermediate to Intermediate System and Open Shortest route first.
- Applicable in improving movement of robotic systems.
- Used as subroutine in other algorithm, For e.g. Johnson's.

III. LITERATURE REVIEW

e-Learning is one of the best outcome brought forward by transformation of the internet. It has made users capable of gathering education and knowledge along with it fruitfully from different resources out there and effectively utilize it to learn and rapidly obtain up to date information. Different problems require different solution and similarly different types of e-learning include blending and informal learning, network-based learning. Both asynchronous and synchronous methodology of e-Learning are equally important. e-Learning is a modern solution to train and help workforce in acquiring required knowledge and skills which are needed to turn change into an advantage and create more opportunities. As a result, many corporations have realized that e-Learning can be used to help keep their employees stay updated with new advances and add new skills to keep providing better solutions and that synchronous tools should be used hand in hand with asynchronous environments to allow for 24*7 available learning model. e-Learning has been proven to be very effective in current situation of covid. e-Learning has made it possible to provide education anytime, anywhere. e-Learning can successfully replace Campus-based Classrooms and help in improving Student Performance.

IV. DESIGN AND ARCHITECTURE

We see a significant gap between theory and practical understanding of algorithms. This is also true for shortest path algorithms and in particular for Dijkstra Algorithm. The main goal of the e-learning tool is to use it for studying known graph algorithms. Starting with the Dijkstra, other shortest path algorithms will also be implemented gradually. The main idea of the system is to provide an integrated educational environment to facilitate the learning process in efficient way. The Pathfinding Visualizer tool involves three steps:

1. Selecting Algorithm
2. Placing Nodes
3. Visualizing

A. USE CASE DIAGRAM

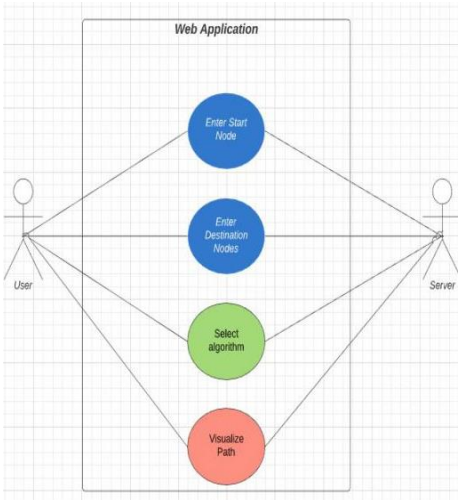

Fig.1. Use Case Diagram

ACTIVITY DIAGRAM

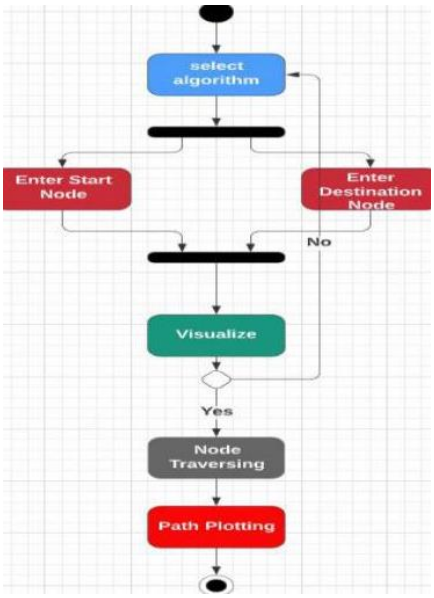

Fig. 2. Activity Diagram

V. PROBLEM ANALYSIS

In recent years, we have seen huge growth in computer science education. There are many difficult topics in computer science , that are very complex to learn and in particular algorithms like shortest path algorithms, these are often hard and complex to understand. Modern technologies has proven to be a boon for learning process. Visual aids have been recognised as means to amplify learning capabilities of an individual. Visualisation makes understanding the explanation of a particular topic surprisingly easy.

We seek to build such an e-learning tool ,using which one can learn path finding algorithms through visualisation of every step of working of algorithm. Features of the tool:

- Easy to use
- Ensure visualization better by adding animation
- Ability to add obstacles in the path

VI. MERITS OF PROPOSED WORK

- Visual aids are widely known as amplifiers of learning capabilities. This tool simplifies the whole process of learning complex path finding algorithms and make it convenient to rely on e-learning tools.
- Visualization through different algorithms gives an individual more autonomy in their leaning journey and helps in finding more real life applications.
- Visualization helps to construct knowledge and to organize the information.
- User having no knowledge about the topic can also learn by seeing.
- Leads to better retention and also promotes active learning.

VII. SYSTEM DESCRIPTION

The project consists of different modules that perform various task. These modules are algorithm module, node module and pathvisualizer module. These modules can be implemented within the home network and over internet as well.

A. Algorithm Module:

The algorithm module is the most important one. It contains the needed function for traversing the nodes on the grid and solving of the graph shortest path problem. This module contains Dijkstra'a algorithm, A* and DFS algorithms as well. We can move in only four ways: Up, Down, Right, Left. This means that all the nodes are equally weighted.

B. Node Module:

When the algorithm starts the search for the destination node and begins the traversing as per the function, the node module covers the creation of animation that shows the direction of traversal and the nodes being traversed. It also takes care of the animation during path plotting between source and destination node on the grid.

C. PathVisualizer Module:

The PathVisualizer Component handles the mouse operations, implements the algorithms of algorithm module on the grid and handles all operation performed on the grid.

VIII. GUI DESIGN

The GUI shows the path plotting using different algorithms.

Fig. 3. Dijkstra's Algorithm implementation

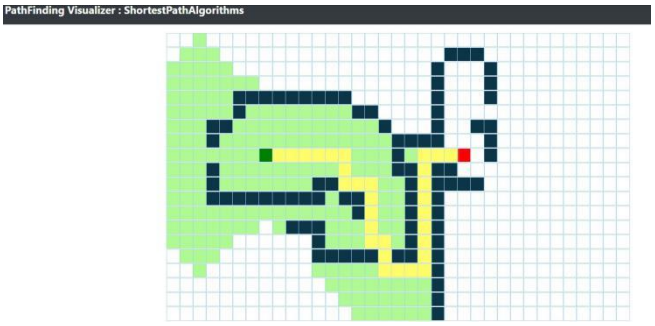

Fig. 4. A* Algorithm implementation

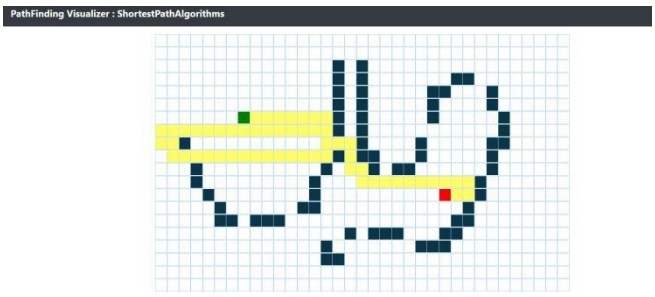

Fig. 5. DFS Algorithm implementation

IX. CONCLUSION

e-Learning is a modern solution of providing education and knowledge. Different tools are being made for the purpose of implementing this method of learning and also to make people realize its importance and adopt it. Both synchronous and asynchronous methods of learning are equally important. e-Learning tools accommodates everyone's need, from a beginner to the expert and their consistency also proves their effectiveness again traditional ways. The web application helped in visualizing the working of pathfinding algorithms and made it look quite quite easily understandable.

Further development of this tool can include visualization of more complex algorithms, implementation over real world map.

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