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Data Structure Algorithms [DSA] Visualizer

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ABSTRACT: This paper presents a web-based Data Structure and Algorithm (DSA) Visualizer designed to support students, educators, and programmers in grasping complex computational concepts. The DSA Visualizer provides real-time, interactive visualizations for a range of data structures (e.g., arrays, linked lists, stacks, queues, trees, graphs) and algorithms (e.g., sorting, searching, and pathfinding algorithms). Unlike traditional text-based learning methods, this tool enables users to observe step-by-step processes and visualize the internal states of data structures and algorithm operations. The DSA Visualizer promotes active learning and enhances comprehension of core concepts in computer science. User feedback and assessments demonstrate that the visualizer improves retention and engagement, making it an effective aid for both self-directed and formal learning environments.

I. INTRODUCTION

The study of data structures and algorithms (DSA) is fundamental in computer science education. However, due to the abstract nature of these concepts, learners often face challenges understanding how algorithms operate and manage data internally. Traditional teaching methods, relying on textbooks and static diagrams, fall short of conveying the dynamic processes involved in DSA operations. To bridge this gap, interactive visualization tools are gaining popularity for their ability to make these concepts more accessible and engaging.

This paper discusses the development, features, and evaluation of an interactive DSA Visualizer that aims to improve the learning experience by providing real-time feedback and animations for a wide variety of algorithms and data structures. By transforming abstract concepts into interactive visual elements, this tool supports users in building a deeper understanding of DSA fundamentals.

II. LITERATURE SURVEY

Web-based Algorithm Animation uses simple command language to create animations of data structures and display them through a web browser. The system is built on JS so it can be used on any machine. Animation to be created is written in simple script language. A text file can be easily transcribed into any text editor or can be generated as an output. Texts have one command or image function per line. The JS applet returns the command file and executes it. The system interprets commands by line and performs specific functions for each command. JS provides commands that allow users to create and move both archeological objects such as circles, rows, text, rectangles, etc., and data structure objects such as columns, stacks, rows, columns, trees, graphs etc. The interface of the system contains animation. canvas and panel that gives users controls such as start, stop, pause and step animation. To control the animation speed the scroll bar is also provided.

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III. BACKGROUND AND MOTIVATION

Importance of DSA in Computer Science
Data structures and algorithms form the backbone of efficient software development and problem-solving. Mastery of these concepts allows developers to create optimized and effective code for complex tasks.

Challenges in Learning DSA
Concepts in DSA can be difficult to grasp, particularly for beginners, due to their abstract nature. Students often struggle to visualize processes such as memory allocation, recursion, and iteration in data manipulation.

Benefits of Visualization in Education
Educational research supports the use of visual aids in improving comprehension and retention of complex concepts. Interactive tools, such as algorithm visualizers, allow users to see changes in real-time, offering a more intuitive grasp of abstract data structures and operations.

IV. METHODOLOGY

In this project, we aim to develop an effective algorithm visualizer tool that can engage students to remain on platform and improve learning outcomes. To achieve this goal, we analyse the pedagogy, usability and accessibility goals of the online students and incorporate the features of the above goals to design effective user interactions and visualizations for an online algorithm visualizer tool. In this design process, we involve three basic activities:

- Establishing requirements
- Designing alternatives and prototyping
- Evaluation

In the establishing requirements activity, we conducted a comprehensive survey on the existing literature, which determines the goals and their relevant features. At the designing alternatives and prototyping activity, we designed the user interactions and the visualizations, where we followed the Schneiderman's eight golden rules of user interaction design [9]. In this work, we mainly highlighted the establishing requirements and designing alternatives and prototyping activities. The evaluation activity is currently in work-inprogress, and it will be done based on a set of Likert survey questionnaire.

V. ALGORITHMS

Sorting Algorithms:
A sorting algorithm is used to rearrange the array or list of numbers according to a comparison operator on the elements. List of elements can be arranged in ascending or descending order as per comparison operator.

Searching Algorithms:
Searching algorithms are developed to check or retrieve an element from a data structure where it is stored. These algorithms are classified in 2 main types based on the type of search operation
Linear search: In this algorithm the list of array is traversed sequentially and every element is checked.
Interval Search: This algorithm is specially developed to search in a sorted list of elements. It is more efficient since it does not check all the elements
Example: Binary search

Path-finding Algorithm:
There are many problems in computer science that needs user to find the shortest path between set points to solve such problems Path-finding Algorithms are developed.

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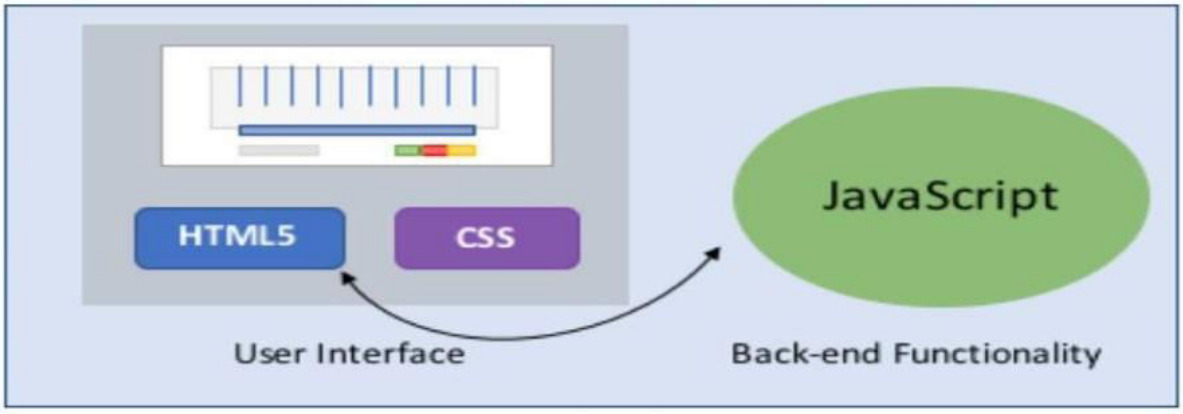
VI. PROJECT ARCHITECTURE



The proposed system includes the visualization of algorithms such as sorting, Searching and path-finding algorithms. HTML5 and CSS are used for interface. HTML5 communicates with React Js code and vice versa to visualize the particular algorithm and update the interface accordingly as shown in Fig I with bidirectional arrow.

VII. CONCLUSION

This paper introduced a web-based DSA Visualizer that serves as an interactive educational tool for exploring data structures and algorithms. By translating abstract concepts into visual representations, this tool offers an engaging and accessible way for learners to understand and retain complex information. Future work will involve expanding the visualizer to include more advanced algorithms and integrating machine learning techniques to tailor the visualizer's suggestions to individual user needs.

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