JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue

JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)

An International Scholarly Open Access, Peer-reviewed, Refereed Journal

REVIEW: AN AR APP FOR LEARNING DATA STRUCTURE

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Abstract: The AR system presents linked list structures in three dimensions by fusing computer-generated images with real-world surroundings. Students gain a deeper knowledge of the dynamics of linked structures and the relationships between nodes by manipulating and interacting with the members of the linked list in real-time. For users of different ability levels, the system's intuitive movements and user-friendly interfaces enable an engaging learning experience. In addition, the AR program has capabilities that highlight important actions like insertion, deletion, and traversal through step-by-step visualizations. Students may see the results of each action on the linked list thanks to this real-time feedback mechanism, which helps them better understand basic concepts.

Index Terms **– Augmented Reality, Unity, Blender, Vuforia.**

I. INTRODUCTION

The augmented reality app will function independently of other software systems on a mobile device. It will use augmented reality (AR) technologies to superimpose virtual data structure visualizations on the physical world. It is a cutting-edge instructional tool that uses augmented reality (AR) technology to teach data structures [1]. This application offers an immersive and dynamic learning experience for comprehending complicated data structures, mainly aimed at computer science and programming students and educators [2]. Since the data structure course is one of the foundational courses that all students must take, it is the most important and crucial course for majors in computers [3]. It might be difficult to learn data structures and comprehend how different data structures affect performance in the same situation [4]. If a student fails this course on their first try, they usually switch to a different major. On the other hand, switching majors has a big impact on the economy and job market. The implementations of data structures like Stack and Queue are introduced through games [5]. Data structures are taught using visually stimulating content that can be integrated into OpenDSA and is akin to interactive books [6]. It is possible to build detailed, interactive explanations of data structures and algorithms using a domain-specific language [7]. A logical-mathematical object-oriented framework is utilized to help pupils understand the problem solution, by neither causing ambiguity nor uncertainty [8]. Additionally, there are web programmers that may be used to teach pupils about data structures by visualizing their processes [9]. All of the aforementioned methods help students comprehend the ideas behind data structures.

II. System Information

A. Data Structures with Augmented Reality

1) Linked List: A linked list consists of a collection of items that are connected by "pointers" or "references," each of which indicates the location of an object within the list. The pointers must be changed to enable the addition or removal of objects from this linked list. Our application's linked list module shows elements and pointers to assist students in visualizing the linked list. Students see how these pointers move within the list to ensure that no elements are lost as elements are added to and removed from it. Although linked lists come in a variety of forms, we have only illustrated a single kind, which serves as the foundation for comprehending the others. Programmers frequently utilize linked lists, a type of linear data structure, to manage and organize data. Links lists don't need memory to be allocated in a contiguous block like arrays do. They are made up of nodes, each of which has a reference to the node after it in the sequence as well as data. Because of their adaptability, linked lists can be used with dynamic data structures. A node is the fundamental unit of a linked list; it contains data as well as a link to the node after it. The list begins at the head node, which is the first node, and ends at the tail node, which is the last node with a link pointing to null.

Benefits of linked lists include dynamic scaling, effective insertions and removals, and memory that is not pre-allocated. These structures are used in dynamic memory allocation and provide the framework for other data structures like queues, stacks, and symbol tables. Applications that incorporate undo functionality also use linked lists. In conclusion, linked lists offer a flexible method of handling data, especially if its size is erratic or changing. Comprehending their attributes is essential for proficient programming and designing data structures.

2) Array List: One of the first data structures that most students learn is the array list. For students learning programming for the first time, especially when studying Java, the Array list is an invaluable resource. The majority of pupils begin utilizing the Array list well before they comprehend its functionality. Studying the inner workings of an array list and how to create one on your own is a crucial part of studying data structures.

A basic building block of programming, array lists provide a resizable, dynamic array implementation. They are frequently employed in many different applications because of their efficiency and adaptability. Array Lists can adjust their size dynamically at runtime, doing away with the requirement for manual scaling. They offer a useful substitute for static arrays, whose size is set. Array Lists are distinguished in programming contexts by their dynamic resizing capability, which enables effective sequential access through the use of indices. To provide type safety and give them the ability to contain parts of a certain type, they are frequently built as generics. For developers working with dynamic data and applications requiring effective and resizable collections, understanding Array Lists is essential. They are an essential tool in programming because they provide a flexible means of managing and modifying data structures.

3) Stack: Although a straightforward data structure, stack is essential to many computer science applications. One way to conceptualize a stack is as practically piling items on top of one other. The Last In, First Out (LIFO) data structure, which states that the last element inserted is the first to be withdrawn, is crucial to stacks. This is a thorough explanation of stacks, their varieties, and programming applications. The two main operations on a stack, which is a linear data structure, are push, which adds an element to the top, and pop, which removes the top element. In addition, a stack could be able to perform functions like isEmpty, which determines whether the stack is empty, and peek, which shows the top element without deleting it.

B. Unity

Unity is a widely used game development engine supporting 2D and 3D applications, providing a user-friendly environment for interactive experiences. Unity serves as the core development platform for the AR application, utilizing AR-specific features like AR Foundation. Unity's scripting capabilities enable interactive features within the AR environment, allowing users to trigger actions through gestures. Unity serves as the basic development environment for "Visualize and Learn: An AR App for Learning Data Structure." Using a visual editor and powerful scripting capabilities, Unity's integrated development environment (IDE) allows developers to craft a smooth augmented reality (AR) experience. The AR Foundation framework is essential to this project because it ensures compatibility with AR Kit for iOS and AR Core for Android, enabling users on a variety of devices to take advantage of the app's instructional features. Unity's scene management features allow for the creation of unique augmented reality scenes, each devoted to the visualization of particular data structures, such as the minute intricacies of linked lists. A primary goal is user interaction, and Unity's scripting features make it possible to integrate user-friendly controls and gestures. These motions, such as tapping, swiping, or pinching, promote engaging interactions within the AR world, enabling a dynamic learning experience for users browsing linked lists. The app's visual attractiveness is enhanced by animation and transitions made possible by Unity's Animator system, which also makes it possible to depict linked list actions like node insertion and deletion smoothly. Blender or Maya are examples of external technologies that can build 3D models, which Unity's asset pipeline effortlessly integrates. Importing linked list components into the AR environment, including nodes and connections, requires this ability. Further streamlining the development process is provided by visual scripting with tools such as Bolt, which enables developers to design logic and interactivity through a visual, node-based system.

With Unity's build settings, cross-platform deployment is made easier and the AR app may run on a range of AR-capable devices, such as tablets and smartphones. In Unity Editor's Play mode, real-time testing improves the development process by letting developers quickly iterate and improve functionality. To provide a more seamless AR experience, Unity's Profiler tool helps with performance optimization by locating and resolving possible bottlenecks. Multiple team members can work on the project at once thanks to Unity Collaborate and Unity Teams, which enhance collaboration and version control. Rich community forums and comprehensive Unity documentation are excellent starting points for learning, debugging, and exchanging thoughts on AR development and linked list visualization. In conclusion, Unity's extensive feature set makes it the perfect option for developing an engaging and instructive augmented reality application (AR) for learning data structures, with a specific emphasis on linked list visualization.

C. Blender

Blender is a unique open-source 3D creation toolkit designed for both developers and artists. Its animation features enable dynamic character movements, while its modeling tools allow fine sculpting and manipulation of 3D objects. Cycles is a rendering engine of choice for professionals in animation and visual effects because of its reputation for producing high-quality, photorealistic visuals. Eevee, Blender's real-time render engine, enhances workflow efficiency with its fast previews and interactive feedback. Blender provides a full feature set of tools for particle simulation, motion tracking, and compositing. To achieve amazing effects, artists skillfully blend CGI components with live-action video. With Blender's simulation features, users may add realism and depth to 3D environments by creating realistic physics-based animations, such as fluid, smoke, fabric, and rigid body simulations. Even with the deprecation of its integrated game engine in more recent iterations, Blender is still an effective tool for developing and prototyping games, attracting the interest of both academics and game developers. Blender's power comes from its scripting and customization features, which include support for Python scripting for creating new tools, automating tasks, and expanding functionality. Because of its adaptability, users may customize Blender to suit their demands, which increases output and creativity. The success of Blender is largely due to the community, which provides a wealth of user-contributed add-ons, documentation, and tutorials. Because of the collaboration and knowledge sharing that this vibrant and encouraging community promotes, Blender is usable by users with varying ability levels.

All things considered, Blender's extensive feature set, sophisticated capabilities, and open-source philosophy position it as a top choice for 3D development, animation, and visual effects. Its ongoing advancement and broad industry adoption highlight its lasting significance and influence in the production of digital material.

D. Vuforia

PTC Inc.'s Vuforia is a well-known augmented reality (AR) platform that provides an extensive toolkit for crafting engaging AR experiences. With its capabilities, which include object tracking, picture recognition, and spatial awareness, developers can overlay digital material in real time over real-world objects or situations. Developers can design AR applications that can identify and track certain images in the environment by utilizing Vuforia's image recognition capabilities. By doing this, interactions that are initiated by scanning photos of product packaging or magazine covers are made possible.

Moreover, Vuforia facilitates tracking and object detection, enabling AR apps to communicate with three-dimensional objects situated in the real world. With the help of this functionality, AR experiences could become more dynamic and participatory. AR apps can comprehend and engage with the physical environment around them thanks to Vuforia's spatial awareness capabilities. Features like occlusion detection, which lets digital things interact realistically with real-world items, and environment comprehension, which accurately positions digital content and detects surfaces, are examples of this. Because Vuforia is cross-platform, programmers can use it to create augmented reality apps that work flawlessly across a range of hardware and operating systems, such as iOS, Android, and Unity. It seamlessly connects with Unity, expediting the development process and facilitating quick iterations and experimentation.

The ability of AR experiences to continue even when the target item is out of view, thanks to advanced tracking features like extended tracking, improves continuity and immersion. Offloading image recognition duties to the cloud improves scalability and performance. This is made possible by cloud recognition and targets. For developers looking to collect information on user interactions and engagement with their augmented reality applications, Vuforia offers analytics and insights capabilities. This makes it possible to track important performance parameters and optimize for improved user experiences and business outcomes.

All things considered, Vuforia provides developers with a strong platform to build captivating and immersive augmented reality experiences for a range of industries, including gaming, retail, marketing, education, and industrial applications. Its extensive feature set, cross-platform interoperability, and smooth Unity integration make it an invaluable tool for augmented reality development, enabling programmers to realize their imaginative goals for the field.

III. Conclusion

In summary, using Augmented Reality (AR) to teach linked list data structures is a game-changer in computer science education. AR makes learning more fun and hands-on, helping students grasp concepts easily. It adapts to different learning styles, getting students ready for the tech world. Despite some challenges, AR is a cool and innovative tool that can make learning not only about linked lists but also other complex topics more engaging and effective.

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