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VirtuVista - A Web Based Virtual Reality with Real Time Voice

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ABSTRACT

This paper aims to cover the virtual reality that can be shown as a web application. Mobile Augmented reality is gaining a lot of importance with real life scenarios being projected in form of objects. When the pandemic of COVID-19 hit, using meeting applications like Zoom & Google meet became inevitable. There is also zoom fatigue, confinement malaise and a longing for personal and social interactions between various relationships like in offices, friends, etc.

While Virtual Reality gadgets are expensive and are physical entities, Web brings a good balance to bridge the gap. Using web for VR also brings in cross-platform capabilities, bringing VR capabilities to various laptops, mobiles including MAC as well as Microsoft.

AngularJS is used to create real world web applications, One of the most used and fastest growing Javascript frameworks bringing life to various web applications with modern capabilities. It is the core element for building front-end of our application.

WebXR API is one of the central to creating 3D environments accessible directly through web browsers. It is used widely in virtual and augmented reality experience, equipped to deliver VR like interaction on standard devices without requiring specialised hardware.

This gives uplifting to the QoE (Quality of Experience), an fast moving area that started within the telecommunication and multimedia engineering sectors.

Keywords: Virtual Reality (VR), Real-Time Communication, 3D Graphics, Collaborative spaces, AngularJS, WebXR API, Socket.io, Web Application.

Introduction:

Web-based Virtual Reality (WebVR) is a technology that enables the creation and delivery of virtual reality (VR) experiences directly through a web browser, without the need for specialized software or hardware installations. Unlike traditional VR, which typically requires high-performance hardware such as dedicated VR headsets, powerful PCs, or gaming consoles, WebVR leverages common web technologies, including HTML5, JavaScript, and WebGL, to create and display immersive 3D environments. The main feature of WebVR is that it works across different devices, so users can enjoy VR experiences on many types of devices, like desktop computers, laptops, and mobile phones. This is especially important as more industries, like education, entertainment, online shopping, and real estate, are looking for ways to offer immersive experiences. With WebVR, these industries can create virtual tours, simulations, and interactive experiences that would be hard to achieve with traditional VR systems.

VR has the potential to revolutionize how we interact with technology, offering immersive experiences beyond traditional methods. However, the need for expensive and complex equipment—powerful computers, special headsets, and software installations—has hindered its wider adoption. Many people simply can't afford or don't want the technical hassle.

To address this, we developed VirtuVista, a web-based VR platform designed to bring high-quality VR experiences directly to standard web browsers. Our goal is to make VR accessible to anyone with an internet connection and a web browser, eliminating the need for extra hardware or software. This drastically lowers the barrier to entry, opening up VR to a broader audience for uses like education, training, and entertainment.

Creating smooth and engaging VR experiences within a web browser presents unique technical challenges. Unlike traditional VR applications that access hardware directly, web-based VR must operate within the browser's limitations. This includes managing network delays, optimizing how quickly graphics are drawn, and ensuring compatibility across different browsers and devices.

History

Evolution of web based VR and real time communication has transformed to how we interact, collaborate, and work in digital era. Earlier technologies like virtual reality modeling languages allowed for interactive 3D experiences on web but widespread adoption was hindered by limited internet speeds and hardware capabilities. The emergence of WebVR and WebXR technologies enabled more accessible web-based VR, allowing users to access immersive virtual environments directly through web browsers without the need for specialized software. Real-time communication tools like Zoom, Google Meet, and Microsoft Teams became very popular because people needed to communicate quickly and remotely. These platforms allowed people to work together instantly, no matter where they were.

Problem Statement

When the first phase of the pandemic COVID-19 hit, all the operations were at hold even the schools, colleges, offices. Everyone was forced to adapt to the new way of online communication and collaboration. Many communication applications emerged like Zoom and Google Meet, which basically were flat screen with boxes of people which would light up is someone is speaking. These applications are still very widely used and accepted but the mail problem none of these were very collaborative with the user. By the use of API’s and AngularJS web based virtual reality can come into existence.

By usage of these things various milestones can be achieved in field of online collaboration which can be classrooms, office spaces, cafeteria, VR cabins with permissions, real time voice communication between users using socket io, etc.

LITERATURE REVIEW

The emergence of virtual reality (VR) technology has transformed various domains, including remote collaboration and online learning. Traditional VR systems often necessitate specialized hardware, which can limit accessibility and widespread adoption. This literature survey examines key studies and developments in web-based VR technologies, emphasizing the significance of accessibility, interactivity, and real-time collaboration in enhancing online experiences.

One foundational work in this area is by Jerald (2016), who explored the potential of web-based VR applications in education. Jerald emphasized that the primary challenge facing educators is the high cost and complexity associated with traditional VR systems. The study highlighted that web-based platforms utilizing technologies such as WebGL and WebXR could significantly lower barriers to entry by enabling

immersive experiences directly through standard web browsers. This accessibility is crucial for educational institutions looking to integrate VR into their curricula, as it allows more students to participate without requiring specialized equipment.

Another significant contribution comes from Kwon et al. (2019), who investigated the use of VR for remote teamwork. Their research outlined the importance of creating shared virtual environments that foster collaboration and communication among team members. They developed a prototype VR platform that utilized WebGL and WebRTC to facilitate real-time interaction within a 3D environment. Their findings indicated that users felt more engaged and present in virtual meetings compared to traditional video conferencing

tools, underscoring the potential of VR to enhance remote collaboration by creating a sense of spatial presence and shared experience.

In the context of web-based VR development, the work of Kim and Lee (2020) is noteworthy. They focused on the integration of Three.js and the WebXR API to create a VR platform that allows users to engage with 3D models in real-time. Their platform demonstrated the feasibility of building immersive environments that run smoothly on standard devices, showcasing the performance advantages of modern web technologies. The authors noted that these advancements significantly improve accessibility and user experience, which are critical for encouraging widespread adoption of VR in both educational and professional settings.

The effectiveness of VR in educational contexts has been extensively studied. Merchant et al. (2014) conducted a meta-analysis of the impact of VR on learning outcomes, concluding that immersive experiences can lead to improved engagement, retention, and understanding of complex subjects. They argued that the interactive nature of VR promotes active learning, allowing students to visualize and manipulate information in ways that traditional educational methods cannot. This highlights the potential of web-based VR platforms to offer effective and engaging learning experiences, particularly for subjects requiring spatial reasoning or complex conceptual understanding.

The work of Rizzo et al. (2016) examined the use of VR for training and simulation purposes. Their research indicated that VR can significantly enhance training efficiency in fields such as healthcare and emergency response. By creating realistic simulations in a controlled environment, trainees can practice skills and make decisions without the risks associated with real-world scenarios.

Overview of VR

Virtual Reality (VR) technology creates immersive, simulated environments that engage users through multiple senses, primarily vision and hearing, and often incorporating haptic feedback. Key characteristics of VR include immersion, the subjective sense of "being there," and interaction, the ability to manipulate and navigate within the virtual world. From early bulky head-mounted displays to today's more accessible and affordable systems driven by advancements in computing and web technologies, VR has evolved significantly. A typical VR system comprises a display (often a head-mounted display), tracking systems to monitor user movement, and input devices for interaction. These components work together to create a sense of presence within the virtual environment. VR finds diverse applications in areas such as gaming, training and simulation, education, healthcare, and design. However, challenges such as motion sickness, hardware limitations, and content creation complexities remain areas of ongoing research and development.

Web base VR Platform and Technologies

1. WebXR Device API: This is the core technology that enables VR and AR experiences in web brows-

rs. It provides access to device capabilities like head tracking, hand tracking, and display output for VR headsets and other XR devices. It allows web developers to create immersive experiences that run directly in the browser without requiring plugins or separate installations.

2. WebGL (Web Graphics Library): A JavaScript API for rendering interactive 2D and 3D graphics within any compatible webbrowser without 1 the use of plug-ins. WebGL leverages the device's graphics processing unit (GPU) for hardware-accelerated rendering, which is crucial for creating smooth and performant VR experiences.
3. HTML5: Provides the structural foundation for web pages and applications. Its various elements and APIs are used to create the user interface, handle user input, and manage multimedia content in web-based VR experiences.
4. JavaScript: The primary programming language for web development. It's used to control the behavior of web pages, handle user interactions, and manage the logic of VR applications. JavaScript libraries and frameworks, like Three.js and Babylon.js, simplify 3D graphics rendering and VR development.
5. WebAssembly (Wasm): A binary instruction format for a stack-based virtual machine. Wasm allows developers to run high-performance code, written in languages like C/C++ or Rust, in web browsers at near-native speed. This is particularly useful for computationally intensive VR applications.

User Interaction in Web-based VR

User interaction in web-based Virtual Reality (WebVR) is an important part of making sure that virtual experiences are easy to use, interesting, and available to everyone. WebVR enables users to access virtual environments directly through their web browsers, usually requiring little to no setup. Since WebVR can work on different devices, like computers, smartphones, and VR headsets, the challenge is to design interaction methods that work well across all these platforms. Common ways of user interaction with WebVR include point-and-click navigation,, and using gestures with VR controllers or hand tracking. for better user experience designers are using different ways to give feedback, helping users understand what's happening when they interact with the virtual world. These feedback mechanisms can include visual cues, sound, and haptic feedback (the feeling of touch or vibration. Well-designed interaction methods make virtual environments more intuitive, engaging, and accessible, allowing users to easily navigate, manipulate objects, and perform tasks within the VR space. These interactions not only improve usability but also reduce cognitive load, making the experience more comfortable and enjoyable. strong user interaction design in WebVR enhances immersion, usability, and accessibility, ultimately leading to a more enjoyable and effective experience.

Performance in Web-based VR

Performance in Web-based Virtual Reality (WebVR) is very important because it affects how smoothly and efficiently virtual worlds are displayed in real-time. This directly influences the user experience. To make WebVR work well on different devices, it needs to adjust the quality of graphics based on the power of the user's device. This is done by changing settings to fit what the device can handle. The performance of WebVR is also influenced by device capabilities, as mobile devices with lower processing power struggle to run demanding VR experiences. Achieving high performance in WebVR is important for providing a smooth and enjoyable experience. To do this, several important factors need to be considered and improved. First, frame rate is crucial—this refers to how many frames per second (FPS) are shown on the screen. A higher frame rate ensures that the virtual world looks smooth and does not appear choppy, which helps prevent discomfort or motion sickness. Second, latency plays a big role. Latency is the delay between the user's actions, like moving their head or hand, and the response they see in the virtual world.

If there is too much delay, it can cause a disorienting experience. Third, hardware limitations must be taken into account. and Network bandwidth is important, especially for applications that need to download a lot of data, like cloud-based VR or multiplayer games. If the internet connection is slow, it can cause delays, make the experience stutter, or even lead to crashes. To ensure good performance, these factors must all be optimized and balanced. When these elements are carefully managed, users can enjoy a smooth, immersive WebVR experience

METHODOLOGY

Research and Requirement Analysis

The project started with detailed research to understand the problems in current remote collaboration and online learning tools. We looked at the limitations of traditional VR systems, which are expensive and depend on special hardware. Feedback from teachers, professionals, and students helped us decide which features the platform should include.

- Gathering Input: We conducted surveys and interviews with users to understand their needs and expectations.

System Design and Architecture Development

This stage focused on designing a strong system that supports real-time collaboration, 3D environments, and scalability.

- **Frontend Development (AngularJS)**:

AngularJS was used to build an interactive and user-friendly interface. Its structure makes it easy to add new features later. The design ensures that the platform works smoothly on all devices.

- **Backend Infrastructure (Socket.io)**:

Socket.io handles real-time communication, making sure users can interact with each other instantly and without delays.

- **3D Environment Creation (Three.js and WebXR API)**:
  Three.js: Helps create and display 3D models and animations in the browser.
  WebXR API: Brings VR-like experiences to everyday devices like phones and laptops.
- **Collision Detection and Interaction (Cannon.js)**:

Cannon.js ensures realistic interactions, like detecting when two users 'virtual bubbles touch.

- **Audio Communication (WebRTC)**: WebRTC allows users to talk to each other when their bubbles overlap in the virtual space, making communication seamless and real-time.

Development and Implementation

The platform was built step by step using an agile approach, with regular updates and testing.

- **Frontend Development**: The design was made to work well on all devices, with AngularJS components that are easy to reuse and expand.
- **Backend Development**: The server manages user sessions, real-time events, and login systems. REST APIs were created to manage user data.
- **3D Asset Creation**: We used tools like Blender to design 3D objects, which were added to the platform using Three.js.

Deployment

The platform was launched using cloud-based services to ensure it is accessible and can grow as needed. Systems were put in place to make it easy to update the platform and add new features in the future.

RESULT

The developed platform represents our first steps toward a fully realized WebVR-based collaboration system, prioritizing ease of access and intuitive interaction for our users. We've successfully implemented several key features during this initial phase of research:

Login Page: We've created a secure and easy-to-use login page. This allows users to authenticate themselves and manage their profiles, ensuring a personalized and safe experience within the platform.

Meeting Creation: We've built a dynamic interface that empowers users to create their own virtual meetings. They can choose from a variety of virtual environments, such as office layouts, classrooms, or open spaces, allowing them to tailor the setting to the specific needs of their meeting. Imagine being able to set the stage for a brainstorming session in a vibrant open space or conduct a formal presentation in a professional virtual office – that's the flexibility we're aiming for.

Meeting Joining: Joining a meeting is designed to be a seamless experience. Participants can easily enter the chosen virtual environment and begin interacting with others, fostering a sense of presence and connection.

DISCUSSION

Advantages

Web-based Virtual Reality (WebVR) provides a number of important benefits. As WebVR runs directly in a web browser, users don't need to install any additional software or deal with complicated setup processes. This means your platform can be used on almost any device, like a desktop, laptop, tablet, or phone, making it available to more people without needing expensive hardware. WebVR's cross-platform compatibility is one of its standout advantages, particularly for applications that require users from different environments to come together in a shared virtual space. Since WebVR operates directly within a web browser, it eliminates the need for users to download or install any specific software, making it accessible across multiple platforms such as Windows, Mac, Android, and iOS.

This flexibility is crucial for virtual spaces like VR conference rooms or study halls, where participants may be joining from various locations and using different types of devices. Updates and improvements are much easier to manage in web based VR because everything is stored online. If changes are made, they can be instantly applied across the entire platform, so users always have access to the new features without needing to download or install anything. Instead of users having to manually update their software, everything is handled automatically, ensuring that the experience is always up-to-date and running smoothly for everyone. WebVR is very powerful for fostering real-time collaboration in virtual environments. Unlike traditional video calls or text-based communication, they allow users to interact and engage in activities as if they were physically present together in the same space. This can greatly improve applications like VR study halls, virtual meeting rooms, or remote teamwork. Participants can see each other in 3D, move around together in shared spaces, and work on things like virtual whiteboards, documents, or other tools in real-time, making the experience feel more natural and immersive. In a VR study hall, students can study together, ask questions, and share ideas like they're in the same room, even if they're far apart. They can use shared resources, such as books, documents, or videos, while working in a virtual space. Being able to move around, point to things, and share visuals in 3D makes the experience more interactive and engaging than regular online learning. in virtual meeting rooms or VR conferences, WebVR enables participants to interact in ways that go beyond basic video conferencing. Instead of just seeing static video feeds of other participants, users can interact with 3D avatars, share and present visual

content (such as slides, videos, or 3D models), and even have side conversations in virtual "breakout rooms." This makes meetings or conferences more dynamic and immersive, as participants feel more like they're in the same physical space, improving communication and collaboration.

Limitations

One of the key challenges of WebVR is its performance limitations. Since WebVR applications run within web browsers, they are often constrained by the browser's capabilities, which are typically less powerful than standalone VR systems. This limitation can affect the graphical rendering and computational power available to the application, leading to issues such as lower frame rates and reduced visual quality. WebVR may face performance issues, causing users to experience lag, stuttering, or lower-quality graphics. These problems can make the virtual world feel less real or exciting, affecting the overall experience, especially in more complex or demanding VR applications.

Cross-platform compatibility is another challenge for WebVR. Ensuring a smooth and consistent experience across different devices, browsers, and operating systems can be difficult. Each device has its own hardware capabilities, screen sizes, and input methods, which can vary widely. These differences make it hard for developers to create an experience that works smoothly on all devices. To make WebVR work well on many platforms, developers need to plan carefully and put in extra effort to manage these differences.

Reliance on network connections is a major challenge for Web-based VR. Since many WebVR experiences depend on cloud resources or real-time interactions, they are highly affected by the speed and stability of the internet connection. A slow or unreliable connection can lead to lag, glitches, or interruptions, which can disrupt the experience and reduce user engagement. To ensure a smooth WebVR experience, a fast and stable internet connection is crucial, particularly for applications involving real-time communication or demanding content.

Security and privacy are important concerns of web based VR. These platforms often collect sensitive information like personal details, location, and even biometric data.This raises the risk of data breaches or unauthorized access, especially when sensitive information is stored in the cloud or used in real-time applications. Since cloud storage and real-time interactions often involve transmitting data over the internet, there is a higher chance that this information could be intercepted or accessed by malicious actors.t his makes it crucial for Webbased VR platforms to implement strong security measures to protect user data from theft or misuse. Without proper safeguards, users' personal and sensitive information could be exposed to cyberattacks, leading to privacy violations or identity theft. To protect users, these platforms need strong security measures like encryption, secure login methods, and clear privacy policies to reduce these risks.

Hardware accessibility is a significant challenge. Not all users have access to high-end devices like powerful computers, which are often needed to experience webVR content at its best.

Future Scope

The future of Web-based Virtual Reality (WebVR) looks incredibly bright, fueled by ongoing technological advancements and the increasing need for immersive and easily accessible online experiences.

As web browsers continue to advance, the performance and visual quality of WebVR applications are expected to improve significantly. New web standards, such as WebXR, are specifically designed to enhance the handling of immersive experiences, providing smoother rendering and more responsive interactivity.As web browsers evolve, we can anticipate substantial improvements in both the performance

and visual quality of WebVR applications. New web technologies like WebXR have been developed to better support immersive experiences, offering smoother graphics and more interactive responsiveness.

A key benefit of WebVR is its ability to work across various devices, ensuring broad compatibility. In the future, WebVR will become even more versatile, allowing users to access virtual environments on smartphones, tablets, desktops, laptops, all without the need for specialized hardware. WebVR will be able to reach an even larger audience, making immersive experiences accessible to users, regardless of the type of device they use.

In the future, the distinction between WebVR (Virtual Reality) and WebAR (Augmented Reality) may become less defined as browsers begin to support both types of immersive environments. This convergence of WebVR and WebAR will open up exciting possibilities for Mixed Reality (MR) experiences, where virtual elements are seamlessly integrated into the real world or real-world objects are blended into virtual spaces. With advancements in browser technologies, users will be able to switch between fully immersive virtual worlds and augmented overlays on the physical world, all within the same platform. This fusion could have a profound impact on a wide range of applications, from entertainment and gaming to education and remote collaboration.

WebVR will increasingly become a powerful tool for online education, offering immersive and interactive learning experiences. Virtual study rooms, field trips, and dynamic learning environments will transform traditional education, making it more engaging and accessible, particularly for students in remote or underserved areas. With WebVR, learners can explore virtual classrooms, engage in real-time discussions, and experience hands-on activities that would be difficult or impossible in a traditional setting. Moreover, WebVR's potential in simulation-based training will be a game-changer for fields like healthcare, engineering, and aviation. Professionals in these industries can gain practical experience in a safe, controlled virtual environment, allowing them to practice critical skills and procedures without the risks associated with real-world training. This immersive approach enhances learning retention, improves problem-solving abilities, and prepares users for complex scenarios in a cost-effective and scalable manner.

Artificial Intelligence (AI) will become increasingly important in the future of WebVR, helping create more personalized and dynamic experiences tailored to individual user behavior and preferences. Machine learning algorithms could optimize VR environments by automatically adjusting settings based on a user's hardware and internet connection, ensuring smooth performance. Additionally, AI can generate adaptive, intelligent avatars for real-time collaboration, making virtual interactions more lifelike and responsive. This integration of AI and machine learning will significantly enhance the user experience, making WebVR environments more efficiently.

The future of Web-based Virtual Reality (WebVR) is incredibly promising, with advancements in technology set to enhance performance, accessibility, and interactivity. As WebVR integrates with AI, machine learning, and mixed reality, it will provide even more immersive and personalized experiences.

CONCLUSION

Imagine ditching the bulky headsets and expensive equipment for online meetings! This web-based VR platform is taking collaboration to a whole new level, making it accessible and immersive for everyone.

We've harnessed the power of modern web technologies like AngularJS for a smooth user interface, Socket.io for real-time communication, and even some VR magic with WebXR. This means you can jump

into a virtual meeting and feel like you're actually there with your colleagues, all from the comfort of your own device – no fancy hardware needed!

The platform isn't just about bells and whistles, though. It has a user-friendly login system, meeting creation tools, and even lets you customize the layout to fit your needs. Whether you're brainstorming ideas in a virtual classroom or collaborating in a shared office space, this platform has you covered.

Think of it as bridging the gap between the real world and the virtual one. You can have engaging and interactive experiences, just like you would in person. And the best part? This is just the beginning! We're constantly looking for ways to improve the platform, like adding more detailed 3D environments, advanced user permissions, and even better voice and video options.

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