VR Tour - Man and the Living World Museum

Statement of Work – Functional & Non-Functional Requirments

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Background:

Virtual reality (VR) is a simulated experience that employs pose tracking and 3D near-eye displays to give the user an immersive feel of a virtual world. Applications of virtual reality include entertainment (particularly video games), education (such as medical or military training) and business (such as virtual meetings).

VR In Education

In the field of education, VR offers learners an immersive and interactive learning experience, allowing them to comprehend challenging concepts and ideas more efficiently and effectively. VR technology has enabled educators to develop a wide range of learning experiences, from virtual field trips to complex simulations, that may be utilized to engage students and help them learn.

Project Goals

• To develop a new unique experience for the museum in order to attract new and diverse audiences.

• To give a new and accessible way to enjoy some of the museum's content.

• To perform a "remaster" for some outdated content in the museum and deliver said content in a fresh and innovative way.

• To give the museum the ability to continue accepting audience and present its content in a creative manner once it will be closed for renovations.

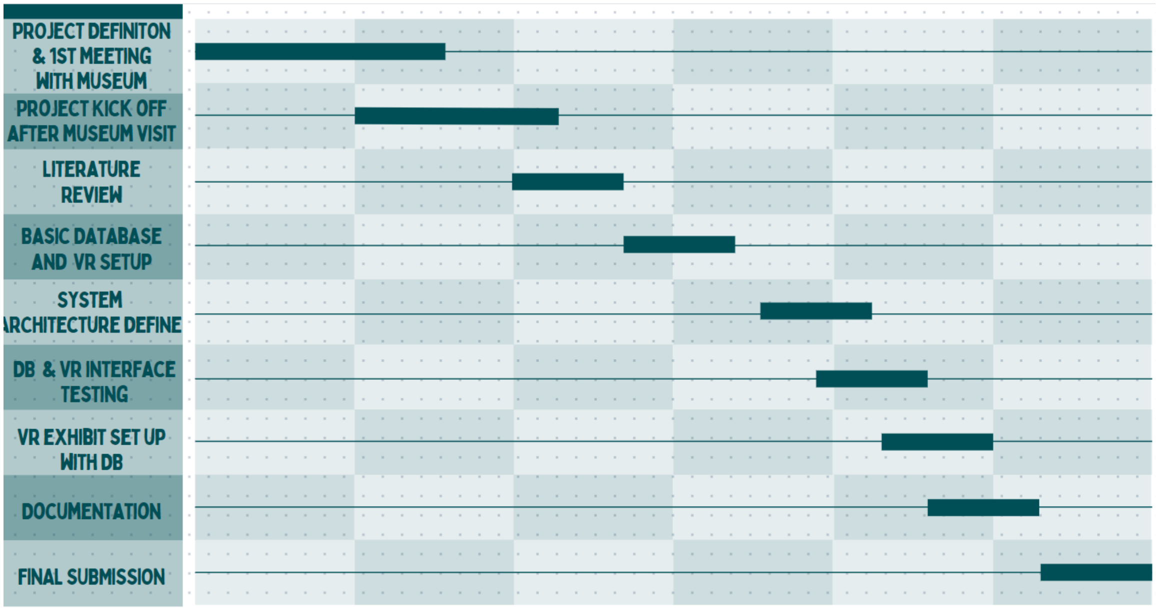
Project Metrics

For our own evaluation regarding the performance, progress, and success of this project, we discuss the following metrics we consider:

1. **User Engagement Metrics**
   - 3D Environment: Regarding the overall experience, we aim to design and reproduce a portion of the museum's environment in the 3d engine, making it at least 80% reliable to the real museum.
   - User Interaction Rate: We are aiming to implement 2 main features for the VR Tour which the user will interact with:
     - VR exhibit – where the user will be exposed to the museum's 3d simulated environment and interact with its objects.
     - Animal Vision Simulation – where the user could get an idea of how some animal visualize the environment.
   - Time Spent in VR Environment: Average duration users spend exploring the VR museum application with the VR headset on, aiming for a 20 – 30 minutes session.
2. **Database Performance Metrics:**
   - Database Response Time**:** Time taken for database queries to execute and return results.

- Database Throughput: Number of database transactions processed per unit of time.
- Data Integrity: Metrics related to the accuracy and consistency of data stored in the database.

Project GANNT:



Initial (High Level) Requirements

Main System Goal

As discussed in our project goals, the main goal is to develop a reliable and interactive VR experience for exploring the contents of the museum, along with integrating a database interface for the purpose of updating exhibits.

Stakeholders

1. **Project Sponsor**: The individual or organization providing funding and overall support for the project. This could be a university department, a research institution, or a company interested in VR technology.

2. **Project Manager**: The person responsible for overseeing the project's execution, ensuring it stays on track, and coordinating activities among team members.

3. **Development Team**: This includes developers, designers, and testers directly involved in building the VR museum application. They are responsible for creating the VR environment, designing interactive exhibits, integrating the database, and ensuring the application's functionality.

4. **End Users**: The individuals who will ultimately use the VR museum application. This could include students, educators, museum visitors, or researchers interested in exploring museum exhibits in a virtual environment.

Functional Requirements

1. VR Environment Interaction:

- Users should be able to navigate through the virtual museum environment using VR controllers.
- Interactive elements such as doors, buttons, and levers should respond to user actions within the VR environment.
- Users should be able to interact with exhibits by selecting, examining, and manipulating objects using VR interactions.

2. Exhibit Display and Information:

- Exhibits should be displayed within the VR environment with accurate representation through 3D models, textures, and animations.
- Information panels or overlays should provide users with relevant details, descriptions, and multimedia content about each exhibit.

3. Database Integration:

- The system should integrate a database to store information about museum exhibits, including metadata such as name, description, artist information, place and time, multimedia assets (images, drawings) within the virtual environment.
- The database should support dynamic content management, allowing administrators to easily create, update, and manage a large mass of exhibitions without requiring significant development effort. This flexibility enables rapid iteration and adaptation to changing museum exhibits or themes
- Database queries should efficiently retrieve exhibit information based on user interactions, exhibit selections, or search queries.
- Users should have the ability to access additional information about exhibits, such as historical context, audio guides, or related articles.

- Implementing version control mechanisms within the database allows administrators to track changes made to exhibitions, revert to previous versions if needed, and collaborate more effectively during the content creation process.

4. User Interface (UI) and User Experience (UX):

- The user interface should be intuitive and accessible, providing clear navigation cues and interactive elements.
- Menus, tooltips, and prompts should guide users through the VR museum experience, explaining controls and options.
- UI elements should be readable and usable within the VR environment, considering factors such as font size, contrast, and placemen

Non - Functional Requirements

1. **Performance:**

   - The VR museum application should maintain smooth performance, with consistent frame rates (e.g., 60 FPS) to prevent motion sickness and provide a comfortable user experience.
   - Loading times for exhibits and database queries should be minimized to ensure seamless exploration within the VR environment.

2. **Scalability:**

   - The application architecture should be scalable to accommodate additional exhibits, features, and user interactions as the museum expands or evolves over time.
   - Database scalability should be considered to handle increasing data volumes and concurrent user access without performance degradation.

3. **Accessibility:**

   - The VR museum application should be accessible to users with disabilities, providing alternative navigation options, audio descriptions, and text-to-speech features.
   - Consideration should be given to users with motion impairments or VR-related discomfort, providing options for seated or stationary VR experiences.

4. **Design**

   - The 3D environments within the VR museum should closely resemble the real museum as much as possible, capturing its architectural layout, lighting conditions, and spatial dimensions.
   - Environmental sounds and ambient noise should be incorporated to simulate the atmosphere of the museum, providing auditory cues that complement the visual experience.

Use Cases

User navigates through the VR museum environment:

- User puts on the VR headset and enters the virtual museum environment.
- Within the VR environment, the user can look around and move using VR controllers or keyboard/mouse inputs.
- The user can explore different sections of the museum, such as galleries, hallways, and exhibition rooms, by walking or teleporting within the virtual space.

User interacts with exhibits:

- While exploring the museum, the user encounters interactive exhibits represented by 3D models or artifacts.
- The user can approach an exhibit and use VR interactions to select, examine, or interact with objects within the exhibit.
- For example, the user can pick up a virtual artifact, rotate it, zoom in to examine details, or trigger animations or audiovisual presentations associated with the exhibit.

User accesses exhibit information:

- Upon interacting with an exhibit, the user can access detailed information about it.
- Information panels or overlays within the VR environment provide descriptions, historical context, multimedia content (e.g., images, videos), and related articles or resources associated with the exhibit.
- Users can engage with this information to enhance their understanding and appreciation of the exhibit's significance and relevance.

Admin manages exhibit database:

- Admin users have access to backend tools or interfaces for managing the exhibit database.
- Admins can add new exhibits to the database, providing metadata such as exhibit name, description, location, and associated multimedia content.
- They can edit existing exhibit information, update multimedia assets, or remove outdated exhibits from the database as needed.

Detailed Design

System Architecture

The system architecture of the VR museum application may include the following components:

- Client-side VR application developed using Unity for immersive user experience.
- MySQL database for storing and managing exhibit data, metadata, and user interactions.
- Communication protocols (e.g., HTTP, WebSockets) for interaction between client and server components.

Performance

- VR application should maintain a consistent frame rate (e.g., 60 - 90 FPS) for smooth user experience.
- Database queries should execute within milliseconds to ensure quick retrieval of exhibit information.
- Loading times for exhibits and database interactions should be minimal to avoid user frustration.
- Server-side components should be scalable to handle increasing user traffic and database load.

Data

- The system shall utilize a distributed database architecture, ensuring data consistency between the museum managers contents and the 3d VR environment.
- MySQL database schema should include tables for exhibits, exhibit metadata, user interactions, and user profiles.
- Exhibit data should include attributes such as exhibit name, description, location, and associated multimedia content.
- Database should support relational queries and indexing for efficient data retrieval and management.

Integration

- The unity engine shall integrate with the MySQL database to import 2D exhibits from the database into a designated area in the 3D VR environment using industry-standard APIs.

User Experience

- Realistic and immersive 3D environments that closely resemble the physical museum.
- Accessible features for users with disabilities, including alternative navigation options and audio descriptions.
- Onboarding tutorials or guided tours to help users familiarize themselves with VR controls and features.

Scalability

- Application architecture will be designed for horizontal scalability to accommodate increasing user traffic and database load.
- VR museum application should be implemented as dynamically as possible in unity, to allow project growth as the museum and its contents evolve.

Security

- User Identification for database access by logging in with a username and password, in basic token, listed users will be managed in a table in the database.

- Security level to restrict access to the database from different users, users could only perform SELECT, UPDATE, and INSERT operations, will be managed in a table in the database.

Technological Requirements

Programming Languages and tools

- C# (C - Sharp) – for programming in the unity engine and implementing the VR environment along with all of its features.
- XR Plugin – A built in library for unity VR development.
- MySQL - for database querying and data manipulation.
- JavaScript – for creating a UI application to interface the DB.
- HTML CSS and React - for web page development.
- Node JS and Git Bash- for React.
- HTTP/HTTPS for API endpoints for client-server communication.

VR Hardware Platforms

- Oculus Rift, Oculus Quest (compatible with quest 1, quest 2, and quest 3).
- Compatible VR controllers for user interaction.

3D Modeling and Animation Tools:

- Blender, for creating 3D models or using unity asset store / other sources for 3D models and assets.

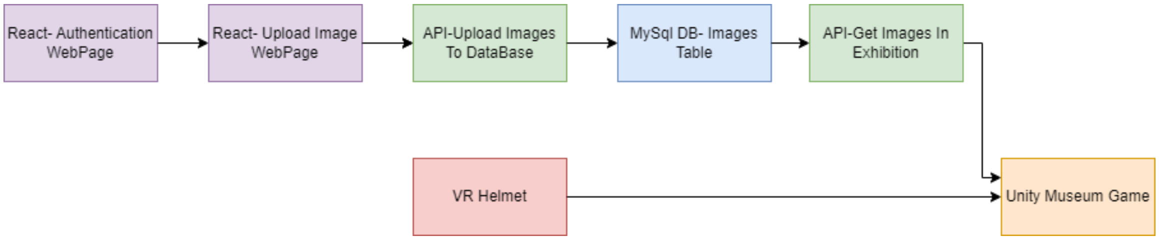
Development Tools

- Git for version control and collaborative development.
- GitHub for hosting and managing code repositories in unity.
- Unity version 2021.3 LTS – for VR application development.
- Microsoft Visual Studio 2022 – IDE for C# scripts that will run in Unity.
- Postman – for web API.
- Java Spring Boot - for DB server infrastructure.
- JetBrains's intellij IDEA – for implementing Java Spring Boot.

Documentation Standards

- Unity design patterns for clean code and scalable project infrastructure.
- Clear and scalable DB architecture.

FLOW:



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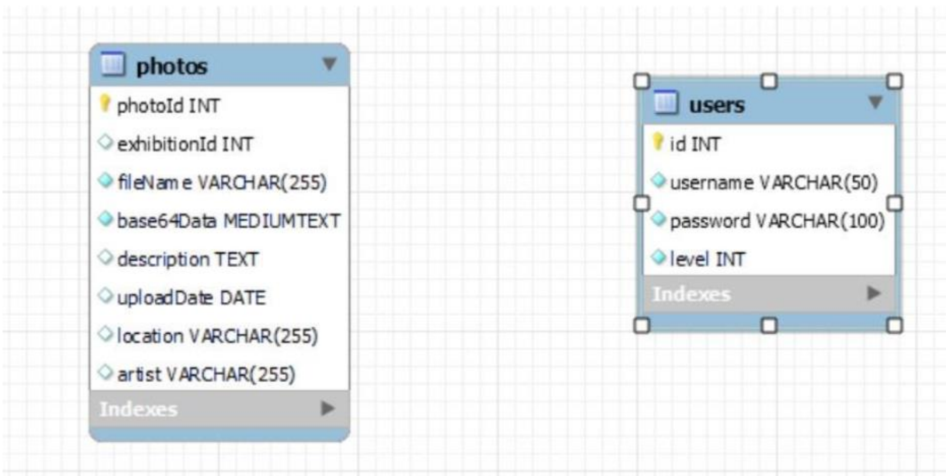
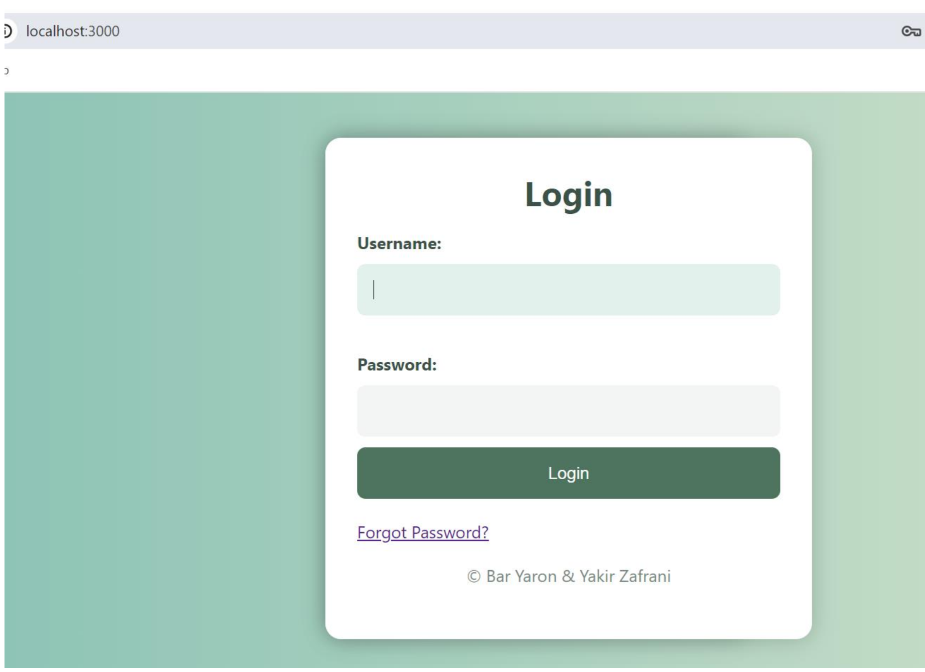
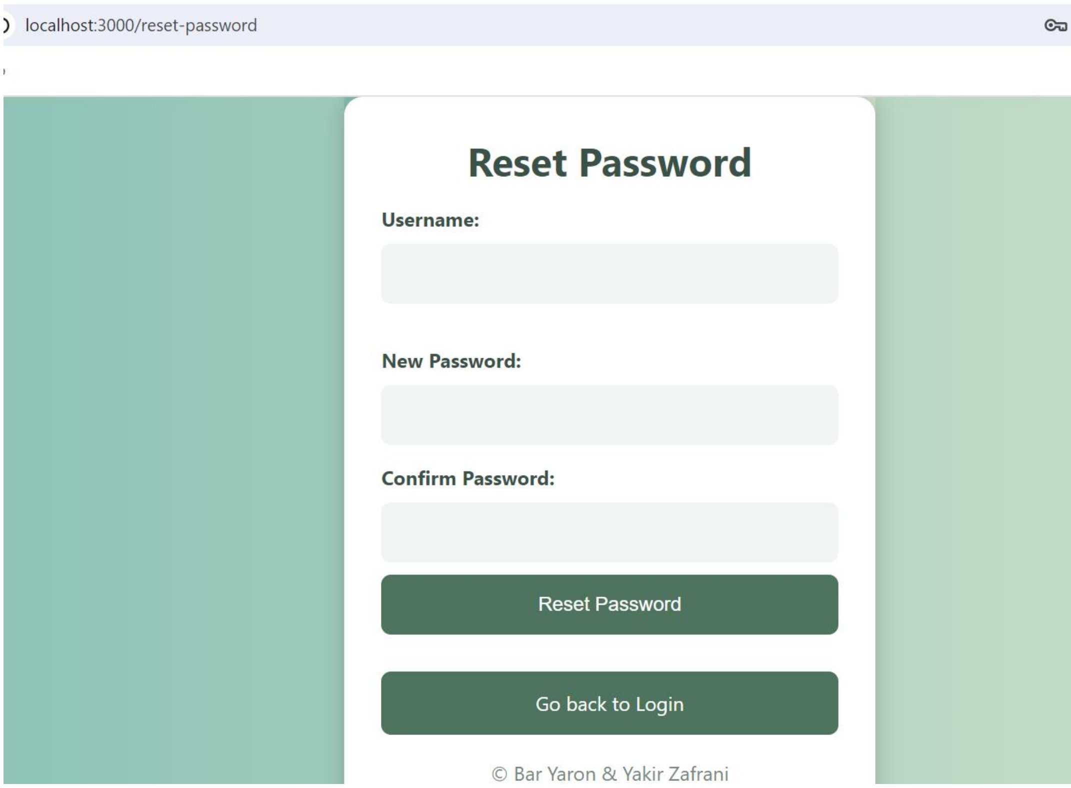


UI Mockups:

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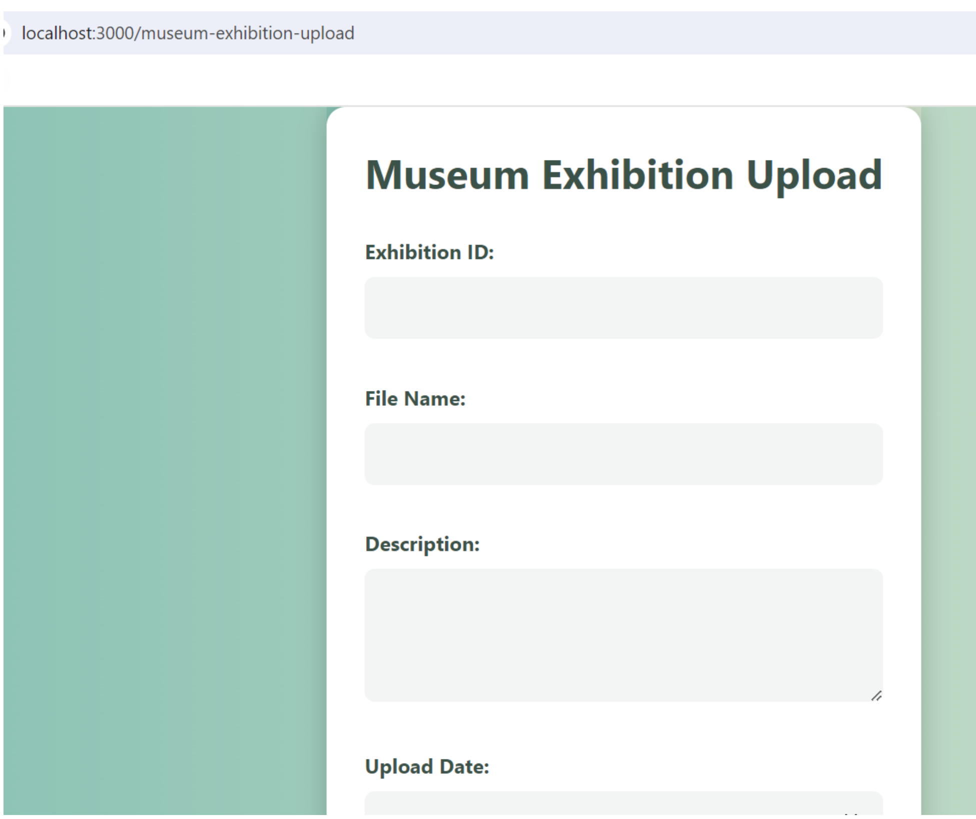
Username:
New Password:
Confirm Password:
Reset Password
Go back to Login
© Bar Yaron & Yakir Zafrani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Museum Exhibition Upload
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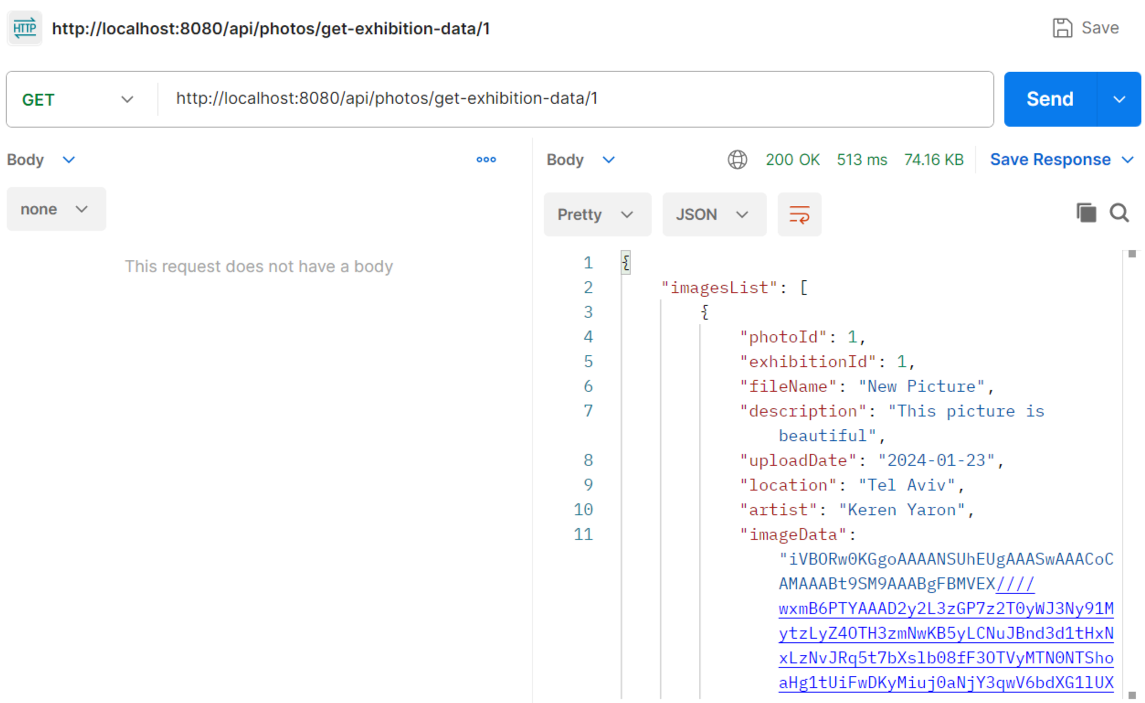
File Name:
Description:
Upload Date:

API Mockups:



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Save
GET
http://localhost:8080/api/photos/get-exhibition-data/1
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Body
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Save Response
Pretty
JSON
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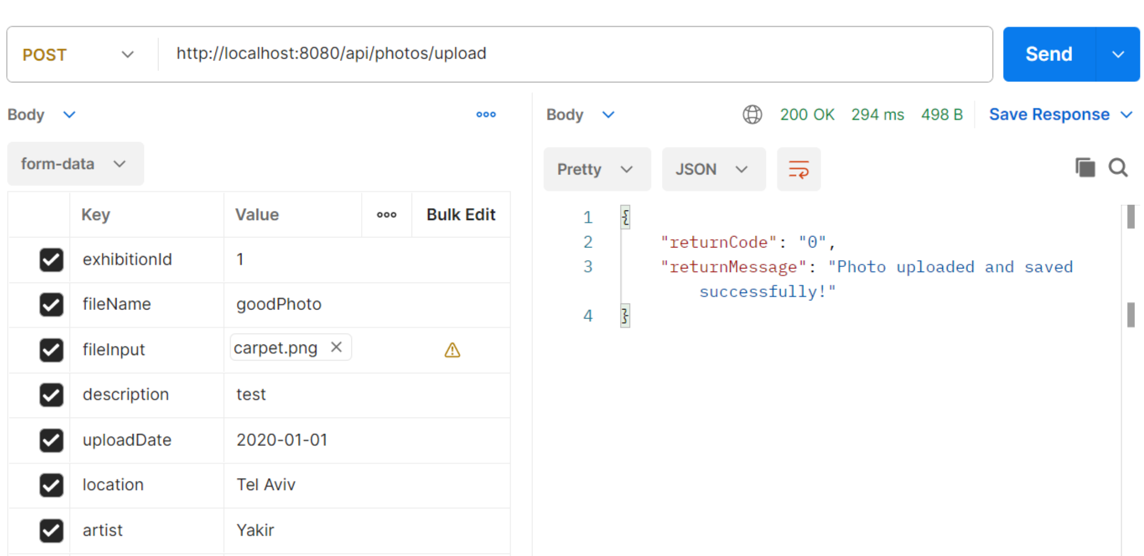

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fileName
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fileInput
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description
test
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location
Tel Aviv
artist
Yakir
Body
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Save Response
Pretty
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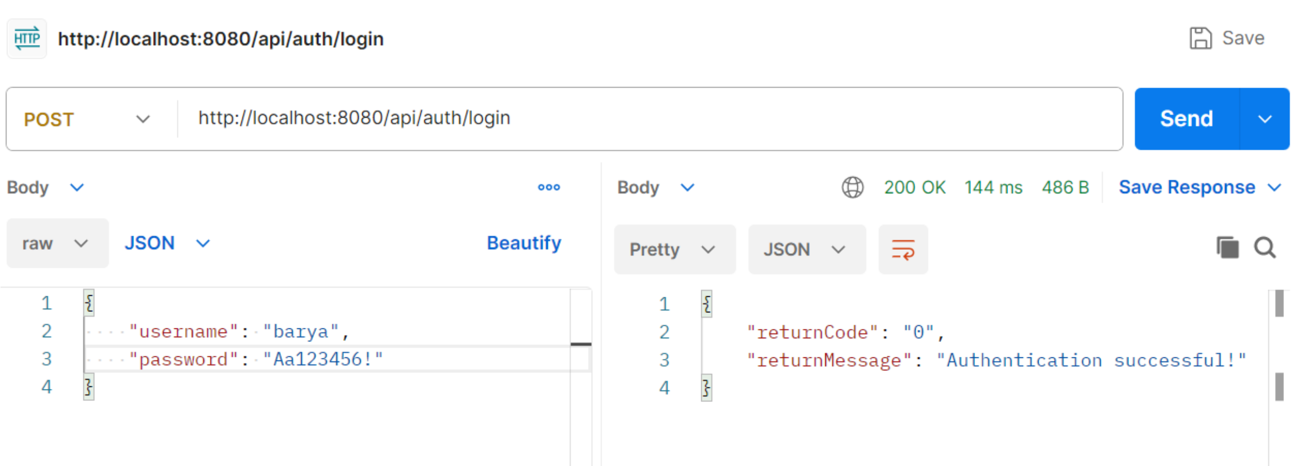
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POST
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Body
raw
JSON
Beautify
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Pretty
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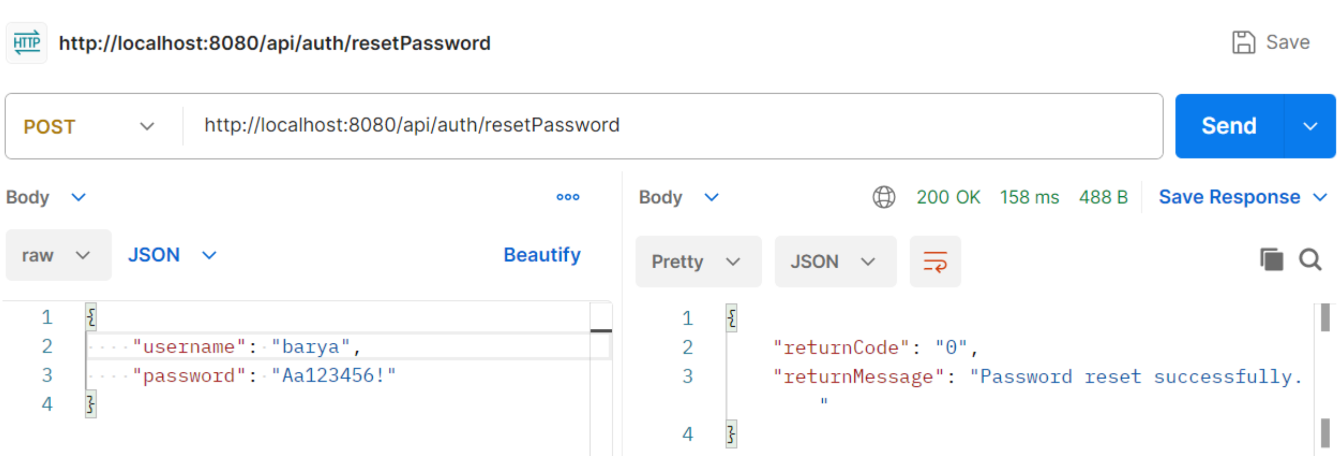
4 }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Save
POST
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Send
Body
raw
JSON
Beautify
1 {
2 "username": "barya",
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4 }
Body
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158 ms
488 B
Save Response
Pretty
JSON
1 {
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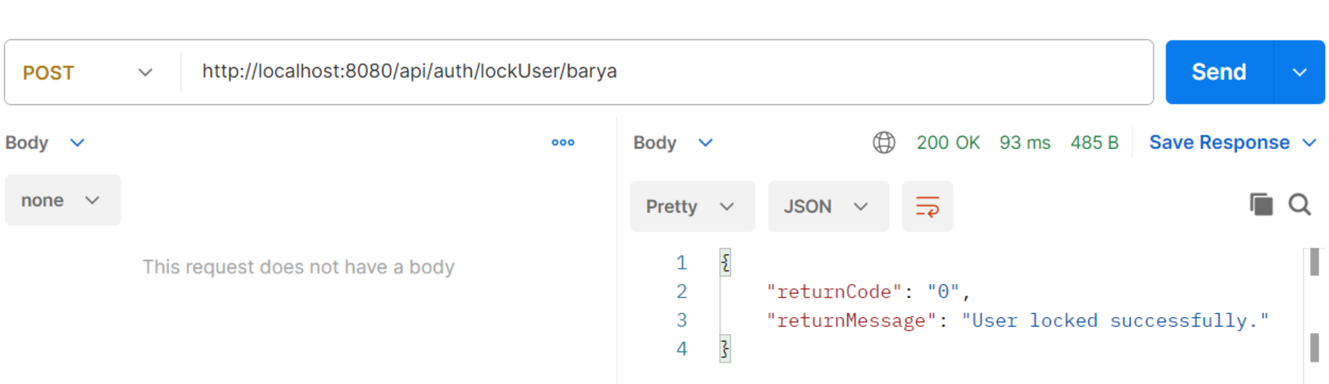
4 }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Body
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Save Response
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JSON
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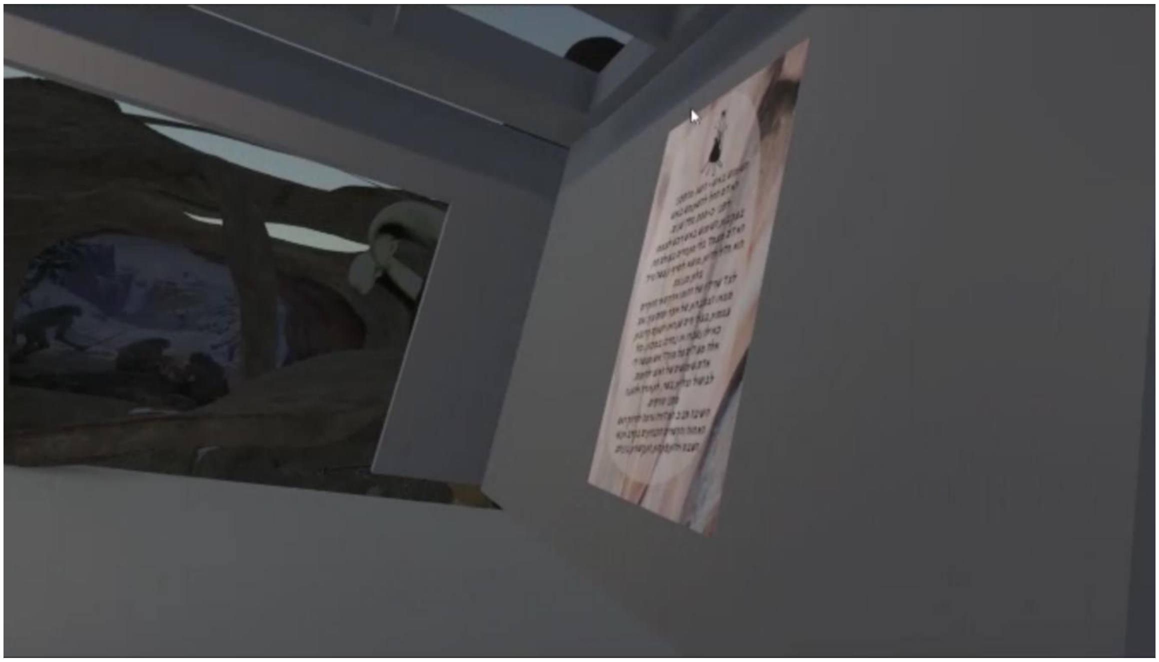

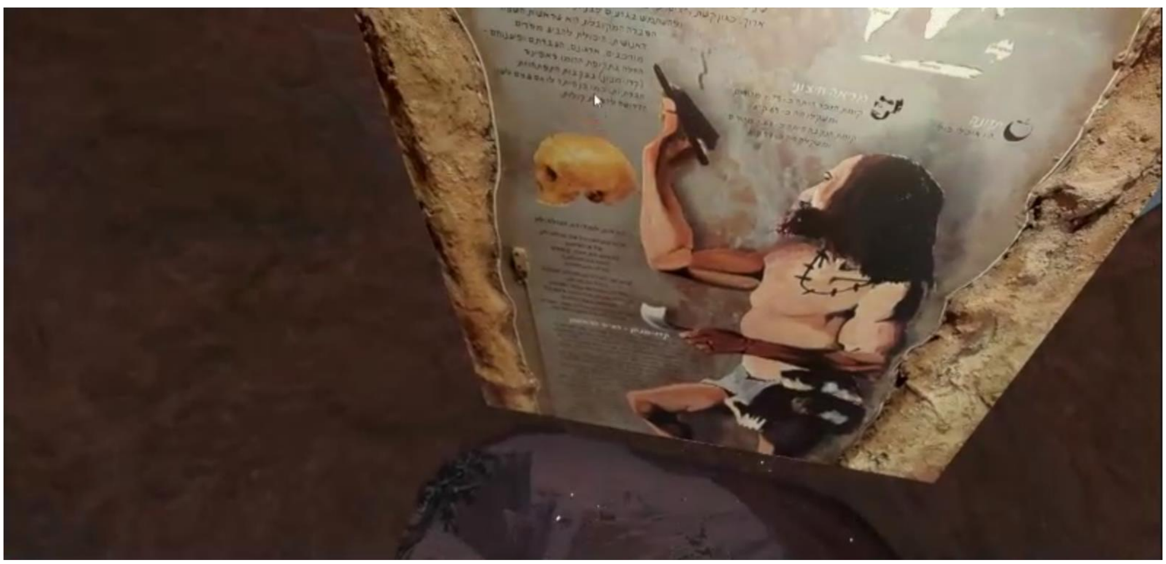

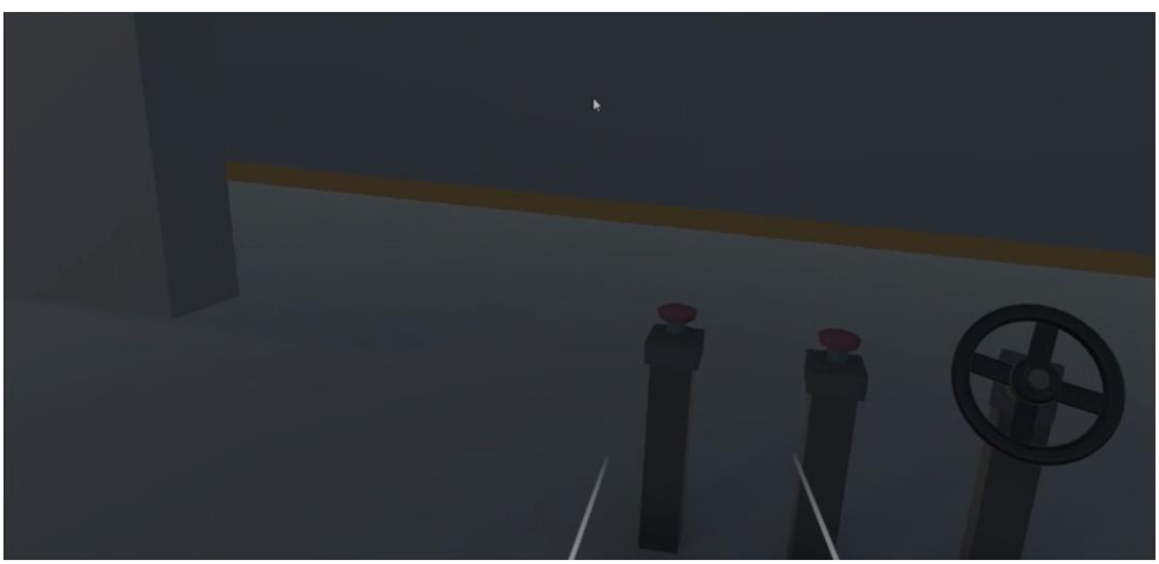

Literature Review

Introduction:

What is Virtual Reality (VR)?

Currently, standard virtual reality systems use either virtual reality headsets or multi-projected environments to generate some realistic images, sounds and other sensations that simulate a user's physical presence in a virtual environment. A person using virtual reality equipment is able to look around the artificial world, move around in it, and interact with virtual features or items using handheld controllers.

How Virtual Reality Technology Has Changed Our Lives: An Overview of the Current and Potential Applications and Limitations (Xudong Huang, Paul B. Tchounwou, 2022)

Introduction:

This study delves into the diverse applications of virtual reality (VR) beyond gaming, examining its potential in education, training, healthcare, simulations, prototyping and beyond. It also addresses gaps in understanding VR's strengths and limitations, offering insights into its future uses and ways to enhance its effectiveness across various domains.

Methodology:

The methodology involved conducting an extensive search across prominent journal search engines/websites like Google Scholar, JSTOR, MDPI, ResearchGate, PubMed, and Science Direct. Keywords such as "VR," "virtual reality," and specific application domains were used to gather peer-reviewed studies and articles. Papers were selected to provide a comprehensive overview of VR applications, focusing on representative and up-to-date evidence rather than exhaustive coverage. A total of 82 sources were utilized, encompassing specific VR applications and domains while excluding studies focusing solely on hardware components or repetitive content. The subsequent sections offer detailed reviews based on various VR applications and domains.

Challenges and Limitations:

Current VR technology faces several limitations. Technological standardization is lacking, leading to difficulties in compatibility and support. Hardware requirements are demanding, causing physical discomfort and potential long-term health concerns. Issues like lag and "cybersickness" persist, hindering user experience. Additionally, accessibility remains a challenge due to high costs and the need for specialized equipment, although augmented and mixed reality offer more accessible alternatives.

Results:

This literature review highlights the vast potential of virtual reality (VR) technology across various fields like engineering, education, medicine, and entertainment. As VR gains popularity, its applications are expected to expand, addressing current limitations and issues. Despite being in its early stages, increasing interest and ongoing development suggest VR could become a commonplace technology in households, akin to personal computers and smartphones. Continued advancements in VR technology hold promise for overcoming current challenges, making long-term usage more accessible and beneficial to a wider audience.

Virtual reality in education: The promise, progress, and challenge: An Overview of the Current and Potential Applications and Limitations (Ryan Lege, Euan Bonner, 2022)

Introduction:

Virtual Reality (VR) presents a promising tool for language educators, yet its evolving nature poses challenges in understanding its potential classroom applications. Initially, differing definitions of VR existed in consumer and academic spheres. While academic literature encompassed various 3D avatar-based interactive experiences, consumer materials predominantly referred to head-mounted displays (HMDs). Despite academic references to non-headset VR experiences, recent focus has shifted towards headset-powered VR. The rapid technological advancements since 2013 have brought new levels of immersion, accessibility, and affordability to VR, particularly in education. However, this rapid innovation renders older research outdated, emphasizing the need for current information. The paper aims to review the benefits and challenges of VR in education, examining both scientific and informal publications from 2017 to 2020 to provide a comprehensive understanding of VR's current state in education.

Benefits:

The benefits of integrating Virtual Reality (VR) into education that are discussed in the paper include:

1. Engagement Enhancement: VR captivates students with immersive experiences, boosting motivation and interest in learning.

2. Access to Inaccessible Environments: VR enables exploration of distant or hazardous locations, providing hands-on learning opportunities.

3. Spatial Memory Enhancement: VR enhances spatial cognition and memory retention through interactive virtual environments.

4. Empathy Training: VR fosters empathy by allowing users to experience different perspectives and social situations.

5. Distance Learning Enhancement: VR facilitates interactive distance learning, enabling collaboration and engagement among remote learners.

These benefits highlight VR's potential to revolutionize education by making learning more engaging, accessible, and impactful.

Challenges and Limitations:

Challenges in applying VR to education arise from the absence of tailored pedagogy for VR environments. While integrating VR into existing educational models is feasible, lacking specific pedagogical frameworks hampers its full potential. Attempting to replicate traditional teaching methods in VR may lead to ineffective outcomes. The difficulty in evaluating VR activities without informed pedagogy contributes to mixed research findings.

Moreover, cognitive demands pose hurdles, as immersive VR experiences can overload working memory, hindering learning. Effective instructional design is crucial to manage cognitive load and optimize learning outcomes in VR settings. Additionally, maintaining immersion is essential; factors like visual aberrations or discomfort can disrupt the learning experience.

Furthermore, introducing VR into classrooms requires a measured approach, allowing students time to acclimate to the technology's unique features. Gender-related considerations, such as discomfort with VR headsets, particularly impact participation in secondary education. Addressing these challenges is paramount for leveraging VR's potential in education effectively.

Conclusion:

The conclusion of the article emphasizes the rapid evolution of technology and its profound impact on human life, including education. It highlights the transition of Virtual Reality (VR) from a fringe technology to a practical tool with clear applications in mainstream education. Despite the initial novelty and engagement of VR, educators must move beyond surface-level benefits and focus on integrating it effectively into pedagogy to avoid it becoming a mere distraction. Additionally, the COVID-19 pandemic has accelerated interest in VR for distance education, potentially reshaping educational paradigms in a post-pandemic era where VR may play a significant role alongside traditional devices.

Why scientists are delving into the virtual world: (Rachael Pells, 2023)

Introduction:

Scientists are increasingly turning to virtual reality (VR) technology to enhance collaboration and remote work. Stephen Hilton, a researcher at University College London, has created a virtual laboratory that mirrors his real-life wet lab, allowing users to interact with equipment and conduct experiments. VR headsets like the Oculus Quest 2 have become more accessible and affordable, enabling researchers to monitor experiments, collaborate internationally, and train students. Hilton's virtual lab, built using software like Unreal Engine, features AI assistants to guide users and offer support. This technology not only improves scientific engagement but also makes science more accessible, particularly in remote or under-resourced areas. The COVID-19 pandemic has accelerated the adoption of VR technology for remote collaboration and training purposes.

Methodology:

Researchers are leveraging virtual reality (VR) technology to enhance training and education in various fields. Koos De Beer from the University of Pretoria utilizes XR-based training tools to create immersive learning experiences that transcend language barriers. De Beer's work focuses on enabling remote visits to hazardous environments like mines and tunnels, particularly benefiting rural areas in South Africa. Meanwhile, Simran Sharma from Cardiff University uses VR to train medical students in recognizing and treating conditions like sepsis, offering a standardized and repeatable method for clinical training. Beyond education, chemist Lee Cronin from the University of Glasgow employs VR to remotely control robots in his lab, streamlining chemical experiments and enhancing productivity. Additionally, neuroscientist Olaf Blanke from EPFL explores the use of VR as a tool for studying human brain functions and perceptions, such as memory and out-of-body experiences, with the aim of advancing treatments for neurological disorders. While VR presents exciting possibilities for scientific research, challenges such as user discomfort and programming limitations persist.

Challenges and Limitations:

Developing VR programs for scientific and research purposes poses significant challenges. Stephen Hilton's experience highlights the complexity involved in creating high-quality VR software, requiring years of development and expertise in fields like 3D computer-aided design (CAD) and artificial intelligence (AI) programming. Limited resources and expertise in labs make it difficult to replicate such efforts elsewhere. While VR holds promise for training and educational outreach, barriers to access persist, including the need for a fast Internet connection, which is lacking in many regions worldwide. In South Africa, for example, connectivity issues are exacerbated by energy blackouts, particularly affecting rural areas. Additionally, there's a lack of understanding and acceptance of VR technologies among some academic circles, hindering wider adoption. To address these challenges, proactive efforts to familiarize people with VR technology are essential, such as creating dedicated spaces like the "XR toy box" at the University of Pretoria to expose students and staff to VR experiences.

<u>Conclusion</u>:

"Is VR merely a fancy toy for scientists to indulge in within the lab?" Cronin candidly acknowledges, "Certainly, it can be seen that way. However, it represents much more than mere play. Throughout history, humans have leveraged tools to drive new discoveries, and VR is simply the latest addition to our toolkit. I don't believe it diminishes human knowledge; rather, it has the potential to transform the very nature of our work, hopefully for the better."

Market Search:

Brief:

The VR museums market search involves an exploration into the growing trend of virtual reality (VR) technology being used to create immersive museum experiences. With the advancement of VR technology in the world, museums and cultural institutions are increasingly leveraging virtual platforms to offer visitors unique and interactive ways to engage with art, history, and science.

In our market search, we are exploring on other honorable museums had that have embraced VR technology to offer immersive experiences, in order to get new insights during our development.

1. **The British Museum, UK:**

   The British Museum has collaborated with Oculus to create a VR experience called "Curators' Corner: Animal Mummies." This VR tour allows users to explore the museum's collection of animal mummies and learn about ancient Egyptian beliefs and practices related to animals and the afterlife. Users can interact with 3D models of the artifacts and listen to expert commentary from museum curators.

2. **National Natual History Museum Paris:**

   In 2018, the National Museum of Natural History unveiled its inaugural permanent VR exhibition, focusing on evolution, a key theme within the museum's broader scope. Upon entering the "Cabinet of Virtual Reality" and donning VR headsets, visitors embark on an immersive journey of exploration. They have the opportunity to closely examine various species, observing them up close and to scale, while uncovering the interconnectedness between them.

3. **The Louvre, France:**

   The Louvre has developed a VR experience in partnership with HTC Vive Arts called "Mona Lisa: Beyond the Glass." This VR tour takes users on a journey through the history and mysteries surrounding Leonardo da Vinci's iconic painting, the Mona Lisa. Users can explore the painting up close in high resolution and learn about its creation and significance through immersive storytelling.

4. **Smithsonian American Art Museum, USA:**

   The Smithsonian American Art Museum offers a VR experience called "Renwick Gallery WONDER 360." This VR tour allows users to explore the Renwick Gallery's renowned exhibition, WONDER, which featured immersive installations by contemporary artists. Users can navigate through the gallery spaces, interact with the artworks, and learn about the artists' creative processes.

5. **National Museum of Natural History, USA:**

The National Museum of Natural History has created a VR experience called "Virtual Reality Dinosaur Exhibit." This VR tour transports users back in time to the Mesozoic Era to explore a virtual dinosaur exhibit. Users can encounter life-sized dinosaurs in their natural habitats, interact with educational content about dinosaur anatomy and behavior, and even participate in virtual paleontological excavations.

Conclusion:

These examples demonstrate how museums around the world are leveraging virtual reality technology to enhance visitor engagement and provide immersive educational experiences. By embracing VR, museums can reach wider audiences, offer unique perspectives on their collections, and bring history and culture to life in innovative ways.

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