BioRealm: A Virtual Zoo

DEESHA MITRA
UG- Student / CSE
Presidency University
Bengaluru, India
DEESHA.MITRA3@gmail.com

SWARNADEEP DUTTA
UG- Student / CSE
Presidency University
Bengaluru, India
SWARNA7D9@gmail.com

DR.VENKATARAVANA N
Assistant Professor, CSE
Presidency University
Bengaluru, India
VENKATARAVANA.NAYAK@presidencyuniversity.in

Abstract*— The conventional methods for zoology have several drawbacks. These include being too expensive and inaccessible and also having little interaction. This article presents a new method called BioRealm as a virtual zoo platform where it will allow users to interactively learn about zoos and their wildlife through immersive experiences. The system has been designed using a lightweight technology stack based on Vanilla JavaScript, HTML5 and CSS3 in order to avoid adding any overhead from frameworks, and to increase the overall performance and accessibility of the system. In terms of the method of the platform, the thematic design is a very strong basis of the platform's design, as it uses a theme of the jungle in order to give the user the experience of walking through the jungle, using a colour scheme of the jungle, rustic typographic style and texture-based UI elements. The most important parts of the platform's design are the navigation component which is a map-based navigation using the so-called BioRealm Explorer, a game-based quiz called the Ecosystem Challenge, using a drag-and-drop format, and a 3D safari, developed using Pannellum.js. The animations of the system were created using the Greensock Animation Platform (GSAP). The article provides the thematic design of the system, the way users can interact with the system and the technical architecture of the system, as well as providing a repeatable model for creating immersive virtual zoos and providing insightful learning.

Keywords—Virtual Zoo, Immersive Learning, Educational Technology, Vanilla JS, GSAP, Pannellum.js, e-Learning, Web Audio API, Interactive Design

I. INTRODUCTION

While physical zoos are enjoyable, they can also be difficult for some people to visit, expensive to maintain and there are issues concerning animal safety. With many animals' nearing extinction or being critically endangered, it would be irresponsible to confine those animals to a small and possibly unpleasant space. Recognizing these issues, digital platforms now offer an affordable, accessible, and feasible way for people to explore and learn about wildlife.

This research explores an idea that will also allow an educational and fun experience called BioRealm, a digital platform that allows users to create their own virtual zoo to experience the different jungles and savannas of the world while experiencing countless species that live in them. BioRealm is designed as a virtual safari experience that offers interactive environments, 360-degree panoramic views of jungles and savannas, and gamified quizzes to help users learn about the animals and ecosystems within the virtual zoo environment. BioRealm was developed using the programming languages of Vanilla JavaScript, CSS3 and HTML, and utilizes animations like Pannellum to create a fully immersive experience.

BioRealm is an attempt to make wildlife education more accessible to students and to encourage learning about species through an interactive and fun environment.

The main goal of BioRealm is to develop an interactive environment that provides all the information that users need to know about each species in order to increase user knowledge. BioRealm is unique because it provides a virtual safari experience with a 360-degree panoramic view of the jungle or savannah and gamified quizzes to make learning about animals' fun and engaging.

A review of the previous literature and in general literature provided a number of key themes and limitations to identify how BioRealm was developed.

II. RELATED WORK

The concept of the virtual zoo has been developed through technical and pedagogical methods. A review of the past literature , in general, the literature can assist us in identifying several themes and limitations that informs the creation of BioRealm.

The authors examined the technical implementations of the project, specifically 3D/VR implementations (e.g., using game engines such as Unity or Unreal), and VR solutions for example Google Cardboard-based options, which are relatively cheap, however, they found that WebGL exports were limited in their capability on lower-end devices and with asset accuracy, and the execution time was less favourable on mobile devices.

File Formats and Technical Pipelines: The authors' study investigated parts of the 3D modelling pipeline to develop some of the file formats (e.g., FBX) and to investigate various optimization methods (e.g., mesh decimation, map-mapping). These two aspects (realism vs. performance) were central to the authors' investigation.

Interactive Advances: Other technologies were also explored by the authors to provide for more than viewing alone. For example, the authors looked at the possibility of providing live telemetry data from IoT sensors into the virtual exhibit.

Pedagogical Evaluation: One of the major deficiencies in the educationally-oriented literature is the lack of rigorous evaluation of how well students learn from virtual exhibits. Many of the studies reviewed had very short-term pilots in the classroom and few if any individual learning studies have demonstrated how to measure learning (e.g., parent-child conversational analysis, pre/post-tests).

Gaps Addressed: The majority of existing virtual zoo apps are either technology-oriented (i.e., focused on 3D rendering) or pedagogy-oriented (i.e., focused on instruction) but not both. Additionally, many of the projects have issues related to performance. As such, BioRealm fills this gap and proposes a reproducible, immersive, thematic-design, high-performance interactive (using Vanilla JS and GSAP) system that emphasizes measured learning success through its intentional Quiz and Explore Yourself modules.

III. PROPOSED METHODOLOGY

The BioRealm System was developed using the methodological approach of designing for an Integrated User Experience; i.e., the visual design, user interaction and animations were developed to support the overall jungle environment theme of the Virtual Jungle. Therefore, the methodology is divided into three primary components: visual design, user interaction, and technical implementation.

A. *Visual Design & Theming*

Our goal is to give users the impression that they are entering a living jungle when using the website versus just accessing a website.

Colour Palette: A rich colour palette of deep greens, earth tones and shadowed blues are used in the visual design. Highlight and button elements are illustrated using highly saturated accent colours (i.e., tropical pinks, parrot yellows and toucan oranges) that evoke images of the jungle.

Typography: Headings are illustrated in a rugged and adventurous font (e.g., Bungee Shade or Rye) to create an exploratory atmosphere while smaller text is illustrated in a compact and readable sans-serif (e.g., Nunito) to ensure readability.

UI Elements: UI elements in the application also have thematic styling. Button elements were illustrated to look like mossy stones or carved wood. Information cards regarding animal species are illustrated to resemble worn journals from a traveller creating a consistent look throughout the application.

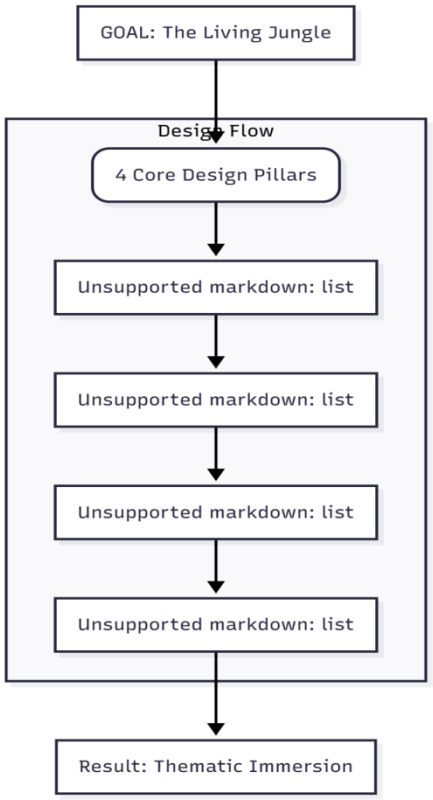

Fig. 1 Visual Design Architecture

B. *User Interaction and Experience*

To attempt to bring the so-called "zoo" to life, our methodology brings the dead pages to life through vibration at discovery.

BioRealm Explorer Map: This is not merely an ordinary menu; it is an interactive biome map. When you click on a region (e.g. Amazon or Congo Basin), you will view the species found in that region.

Investigation of the wildlife: The investigation of species information is in the format of a field guide with interactive buttons (Diet, Habitat, Status) for further information.

Soundscapes: In addition to the interactive buttons there is a "Soundscape" button, which provides an optional background soundscape of the region of the animal using the Web Audio API.

Safari: The safari, which is also a 360-degree virtual tour or scavenger hunt, allows the student to explore the jungle environment and click on hidden animals to read more about them.

Quiz: The quiz is game-based, in the style of a challenge called the "Ecosystem Challenge". The challenge uses a drag and drop method, in which students place the animals in their proper location on a food chain diagram and immediately receive both visual and animated feedback.

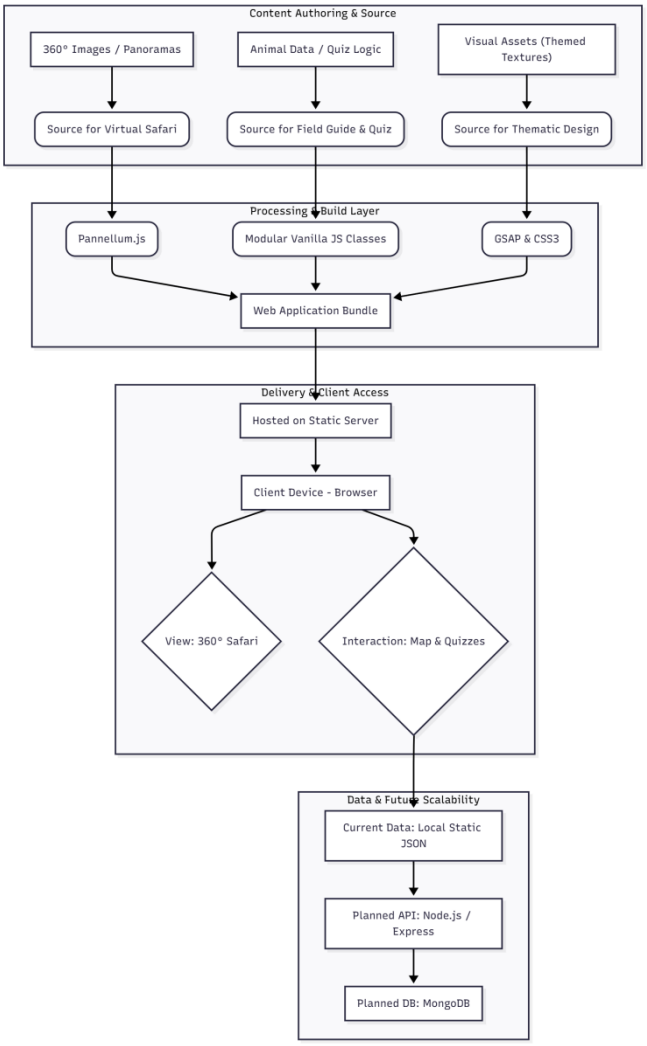

Fig. 2 User Activity Pipeline

C. *Animations and Immersions*

The Animations are used to support the educational goals of the site, rather than to distract from those goals.

Background Animation: Background animation is provided by falling leaves or cloudy fog at a rate that creates a sense of movement without distracting the user.

Micro-Interactions: Hovering over buttons causes them to grow slightly larger or show a leaf icon. Thumbnails of the animals have a soft breathing effect.

Transitions: Themed transitions occur when transitioning between pages, i.e., vines appear to grow into the display frame containing the page content or a page curl effect occurs (i.e., a notebook belonging to an explorer).

Triggered Scroll Effects: Elements (fact boxes, conservation badges, etc.) fade in or slide in based on scroll-directed animation effects triggered by scroll events.

GSAP manages entrance animations, scroll-triggered effects and micro-interactions. GSAP provides the ability to

precisely control timelines to improve perceived performance and polish.

```
gsap.from('.hero-title', { y: 40, opacity: 0, duration: 1 });
gsap.from('.hero-stats .stat', { stagger: 0.15, y: 20, opacity: 0 });
```

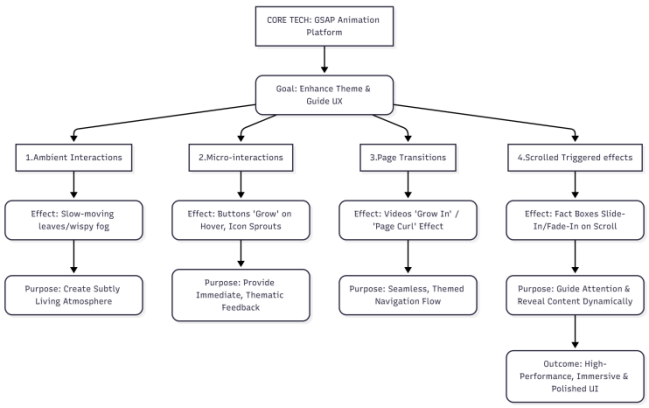

Fig. 3 Animations and immersions engineering

D. Technical Design - Implementation

The project was built using Vanilla JavaScript, HTML5, and CSS3. Using a full-featured front-end framework like React would be unnecessary for this project and could negatively affect both load time and the overall bundle size, both of which are critical to educational accessibility.

Pannellum - Used to render high-resolution, equirectangular panoramic images with animated hotspots. The Pannellum Viewer can be instantiated with a specific scene configuration and custom hotspot handlers. Below is an example of how the viewer is created.

```
//createViewer() Snippet
this.viewer = pannellum.viewer('panorama', {
default: { firstScene: 'jungle', autoLoad: true },
scenes: sceneConfig
});
```

//sceneConfig is an object that holds both the path to each panorama, and its associated hotspots.

Quiz Manager - The Quiz Manager is small and client side. Each question is represented as a JSON-like object and rendered dynamically on the client side. Below is an example of what a single question looks like.

```
{
id: 'food-chains',
title: 'Food Chains & Ecosystems',
questions: [
{question: 'In a typical food chain... ', options:[...], correctAnswer: 0 }
]
}
```

This design allows for immediate feedback and makes it very easy to add additional quizzes.

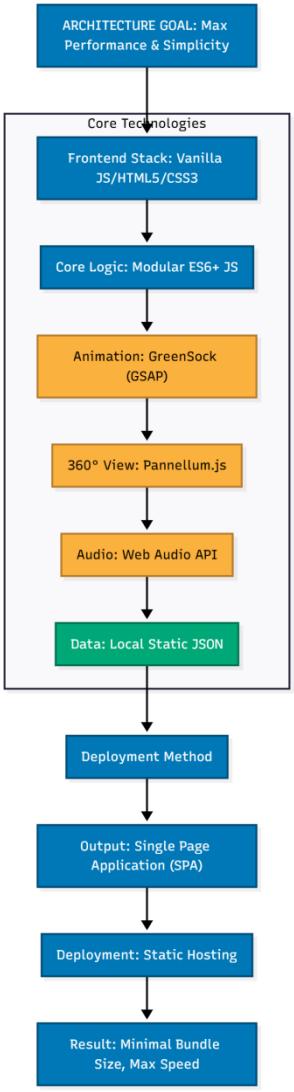

Fig. 4 Technical Implementations Workflow

Core Logic: Rather than use a component-based model like a framework, the application is broken down into modular javascript classes (BioRelmApp, QuizManager, VirtualSafari) to manage state and handle user interactions.

Animation Engine - GSAP (Greensock Animation Platform) is used to power all of the applications complex and high-performance animations (timelines, scroll triggers, page transitions).

Audio - The web audio Api was chosen to allow the most flexibility and control over the application's audio, specifically for creating immersive environments (audioscapes and sound effects for UI) and enhancing the experience by looping ambient tracks per scene, playing short animal sounds while viewing details. The app will utilize html5 audio elements and the web audio api to gain fine grained control over the audio (i.e. gain nodes, scheduling).

```
const audioCtx = new (window.AudioContext || window.webkitAudioContext)();
const bg = document.getElementById('backgroundMusic');
const src = audioCtx.createMediaElementSource(bg);
const gainNode = audioCtx.createGain();
src.connect(gainNode).connect(audioCtx.destination);
```

IV. OBJECTIVES

The BioRealm Project Development Objectives:

A. A virtual zoo platform

Create a virtual zoo with a continuous jungle explorer theme for all visuals, interfaces, and sounds.

B. Food Chain Quiz

To Develop an interactive and educational gamified feature for users, such as a gamified drag-and-drop “Food Chain Challenge” and virtual safari with Pannellum.js.

C. High performance tech stack

Use a front-end technology stack that includes Vanilla JavaScript, GSAP, and Pannellum.js for developing the entire frontend to achieve fast load times and improve accessibility and reduce dependency on frameworks.

D. Animation (GSAP)

Develop ambient, micro-interaction and scroll triggered animations using GSAP to reinforce the jungle explorer theme and support user interaction.

V. EVALUATION AND RESULTS

Validate each individual component and the overall system to verify the effective operation of each component as well as the complete system.

A. System performance evaluation

This step will be focused on technical validation.

Optimization: Compare the effects of the Vanilla JS implementation through comparison of the bundle size of a hypothetical one built using a low-cost mobile device and the load time (First Contentful Paint) and runtime performance (smoothness of animations) of the current implementation to validate the ability of the lightweight stack to create a physical accessibility advantage.

B. Learning Efficacy

Pilot studies using student groups will be carried out to assess the educational effectiveness of the platform.

Knowledge Gain: Quantitative assessment of this will be through the analysis of the results of the “Food Chain Challenge” quiz.

Engagement: User Engagement will be measured using analytics, the amount of time users will spend inside the Virtual Safari, the number of clicks they make on tabs to access species information, and their completion rate for the quiz.

User Experience will be assessed by the Pilot Groups' Qualitative Reports regarding the Thematic Design, Usability, Drag-and-Drop Interface, and 360 Degree Interfaces of the Virtual Zoo.

VI. DISCUSSION AND LIMITATIONS:

BioRealm proves that even without using extensive technology stack, an interactive and educational platform to learn about different species present in our jungles and savannas are possible. The current database can be scalable as and how new species are found and researched about in the future. In the testing of the platform, users have liked the platform, have stated it as a useful and enjoyable way of learning. They have especially mentioned about the interactive quiz and that that the results of the quiz always motivated them to learn more. Although the platform learns successfully and delivers the main intention, it is still under development to make it the ultimate place for wildlife education.

Limitations: BioRealm is a complete online-based platform. Few features of BioRealm are always dependent on the internet. This has to be worked on to make it offline completely. The mobile-view of the platform also differs from mobile model to model. This can also be a limitation as the UI of the platform may show some abnormalities. The Biorelam is continuously updated and rectified in each step to make it user friendly and limitations free.

VII. CONCLUSION AND FUTURE WORK

This paper describes the Architecture, Methodology and Evaluation Plan for BioRealm, a Virtual Zoo, developed using Vanilla JavaScript. BioRealm addresses three major shortcomings of previous research efforts in terms of Performance, Engagement, and Immersion through a strong interactive design and libraries such as GSAP and Pannellum.js. As explained by the Methodology behind BioRealm, it is possible to obtain an intensive, interactive, and educational experience without having to depend on large Frontend Frameworks, while prioritizing Accessibility and Speed of the output.

BioRealm provides a solid foundation for continued development. The key next steps include:

Moving to 3D: Migrating the Virtual Safari to explore 3D environments using Three.js Migration of the 360-degree photos (Pannellum.js).

Backend Integration: Developing a complete backend API (i.e., with Node.js and MongoDB) to allow users to modify dynamic content, access their own user account, and store their individual progress through the quizzes.

Content expansion: Adding new biological concepts to the Explorer Map and creating new game-based modules centred on biological concepts to make it enjoyable to the learners.

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