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HERITAGE QUEST: AN IMMERSIVE 3D CULTURAL JOURNEY IN UNREAL ENGINE

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Original Article

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Abstract

In recent years, the youth of India have shown declining interest in learning about the country's rich cultural heritage, primarily due to the monotonous and text-heavy methods traditionally used to convey historical information. Current systems often rely on static content, such as textbooks and websites, which fail to engage younger audiences who seek more interactive learning experiences. While some digital platforms attempt to make heritage learning interesting by offering multimedia content like videos or articles, they still lack interactivity and personalization. Heritage Quest addresses this gap by offering an interactive, avatar-driven web-based game that transforms heritage exploration into a fun, engaging experience. Through an immersive map of India, youth can explore famous and lesser-known monuments, interact with AI-powered gatekeepers, and engage in trivia challenges. By incorporating AIML-based text summarization and dynamic question generation, the game turns traditional heritage learning into a lively and interactive journey, encouraging the youth to discover and appreciate India's diverse history in a way that feels more like an adventure than a lesson.

Keywords: Cultural Heritage, Interactive Learning, Exploration, Gamification, Historical Sites, AI-Powered Trivia, Dynamic Quiz System, 3D Visualization

Introduction

In recent years, the youth of India have shown a declining interest in learning about the country's rich cultural heritage, largely due to the reliance on traditional, text-heavy educational methods that fail to engage modern learners. India, with its vast and diverse cultural legacy, is home to countless historical sites, monuments, and narratives that remain underappreciated, particularly among younger generations. The absence of interactive and engaging platforms has resulted in disconnect between the youth and their cultural roots, leading to a gradual fading of historical awareness. To address this challenge, Heritage Quest has been developed as an interactive web-based game that redefines heritage learning by integrating exploration, technology, and gamification. The system features a dynamic map of India, allowing players to navigate through various historical sites and immerse themselves in rich cultural narratives. As players explore these locations, they engage with interactive artifacts, uncover historical details, and participate in AI-generated quizzes designed to reinforce their learning. The game leverages modern technologies such as Flask for backend management, SQLite for efficient data storage, and Blender for optimized 3D asset creation, ensuring a seamless and visually engaging experience. Additionally, the structured quiz system categorizes questions into different difficulty levels, rewarding players with achievement-based progression through Bronze, Gold, and Elite cards. By combining interactive storytelling, educational content, and an engaging gameplay structure, Heritage Quest aims to bridge the gap between

cultural heritage and modern learning methods, making history more accessible, interactive, and enjoyable for users of all ages.

Related Works

Traditional methods of heritage education, such as museum visits, textbooks, and documentary-based learning, have long been employed to impart historical knowledge [1]. These methods, while structured and credible, often fail to engage younger audiences due to their static nature [4]. Recent advancements in educational technology, such as multimedia-based virtual tours and online historical archives, aim to enhance user interaction, yet they still face challenges such as limited personalization and user participation. The integration of gamification and interactive elements has shown promise, but heritage-focused games often rely on pre-existing question banks, limiting the ability to dynamically generate content based on user interactions [5]. These issues highlight the need for more engaging, adaptive digital heritage learning experiences that cater to modern learner expectations.

A common challenge in digital heritage platforms is their passive nature. Static digital archives and virtual museum tours offer valuable cultural preservation but lack features that foster sustained user engagement. In contrast, gamified learning platforms encourage interaction but often present generalized content that does not evolve based on the user's progress [2]. While some AI-driven educational tools generate personalized learning paths, most focus on academic subjects rather than cultural heritage, limiting their ability to offer meaningful cultural education. Furthermore, heritage-focused games typically do not incorporate real-time question generation or adaptive difficulty, which could enhance personalization and long-term engagement [7]. These gaps emphasize the importance of integrating adaptive learning models into heritage education systems to improve user involvement and retention.

Despite the rise of innovative platforms, significant gaps remain in the field of digital heritage education. Many existing platforms lack dynamic, AI-driven quiz generation and personalized learning pathways, which are crucial for engaging users in an evolving and interactive manner [3]. The absence of immersive features such as 3D exploration or augmented reality further limits the potential for deeply engaging cultural learning experiences [6]. As emphasized by experts in the field, integrating AI technologies and gamification into heritage education can help overcome these challenges by offering adaptive and engaging user experiences [9]. These technological advancements are essential to create platforms that not only preserve cultural knowledge but also make it accessible, interactive, and enjoyable for users of all ages.

Proposed Approach

Heritage Quest is a web-based game designed to offer an interactive and engaging way to explore India's heritage. The interactive India map guides players to various heritage sites, where they encounter a gatekeeper who presents a scroll containing historical information along with a basic trivia question. Answering correctly rewards players with a Bronze Card, granting them further access to explore the site. AIML technology is utilized to summarize scroll content and dynamically generate trivia questions. As players navigate the site, they interact with elements like bushes or stones to uncover fun historical facts. Upon reaching the final point, they face trivia challenges of increasing difficulty—Easy, Medium, and Hard—based on the scroll content. Correct answers earn them Silver, Gold, and ultimately, the prestigious Elite Card. Acquiring the Elite Card at one site unlocks access to the next, and after earning Elite Cards for all three sites within a state, players are rewarded with a special avatar costume representing that state.

System Architecture

The system follows a structured architecture represented in figure 1 comprises multiple interconnected modules to ensure efficient processing, scalability, and an immersive user experience. The architecture consists of the following key components:

● User Interface Module: Facilitates interaction between the player and the system, providing an intuitive navigation experience on the interactive map and quiz sections.

● Map Navigation & Heritage Site Selection Module: Allows players to explore an interactive map of India, selecting heritage sites for detailed exploration.

● Site Exploration Module: Provides historical and cultural context of selected sites, ensuring an engaging and educational experience.

● AI/ML-Powered Quiz Generation Module: Uses Gemini AI to dynamically generate quiz questions based on exploration insights, structured across three difficulty levels.

● Progression & Unlocking Mechanism: Tracks players' achievements and progress, unlocking new levels based on quiz performance.

● Knowledge Advancement System: Ensures a comprehensive understanding of cultural heritage through AI-driven interactivity and gamification.

● Database Management System (SQLite): Stores user progress, achievements, and quiz-related data for retrieval and analysis.

● Flask Backend & API Management: Facilitates communication between frontend and backend, handling AI-powered question generation and player data storage.

● 3D Visualization & Interaction Module: Uses Unreal Engine and Blender to create immersive 3D models of heritage sites.

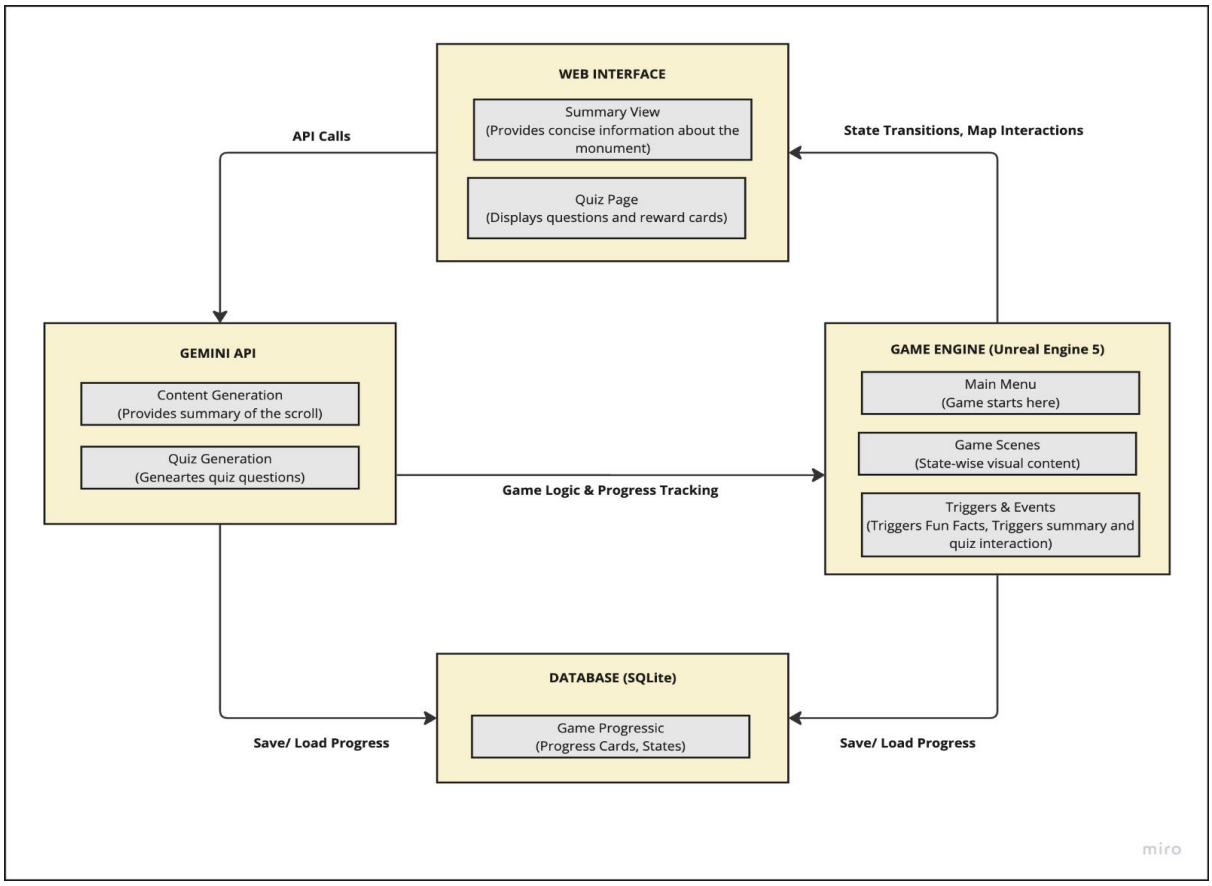

Fig 1: System Architecture

Methodology

The methodology involves selecting and implementing algorithms tailored to interactive heritage exploration, AI-driven MCQ generation, and achievement tracking in *Heritage Quest*. For 3D Visualization & Interactive Exploration, Unreal Engine is used to create immersive virtual recreations of historical sites, while Blender is utilized for detailed 3D monument modeling. In the AI-driven MCQ Generation module, Gemini AI dynamically generates quiz questions based on historical data, ensuring contextual relevance. The MCQ Parsing Algorithm, using regex-based extraction, structures the questions efficiently for in-game presentation. For Achievement Tracking, SQLite manages achievement data, allowing secure storage and retrieval of collectible rewards.

To optimize performance, Thread Pool Executor is used for parallel processing in quiz generation, reducing latency. Additionally, adaptive caching minimizes real-time API call delays, while database indexing improves retrieval speed. Challenges such as high hardware demands, AI integration delays, and concurrency management were addressed by optimizing 3D assets, implementing background AI processing, and refining database queries for better efficiency.

Results

Experimental setup

The experimental setup for Heritage Quest aimed to evaluate the effectiveness and performance of the AI-driven trivia generation and interactive heritage exploration system.

The development environment for Heritage Quest is configured using Windows 11 as the operating system, ensuring compatibility with the necessary tools. The primary software includes Unreal Engine for game development, Blender for 3D asset creation, and Visual Studio Code for coding and debugging. The programming languages used is Python and C++, with essential frameworks like Flask for backend integration and SQLite for efficient data management. AI/ML functionalities leverage Gemini AI and OpenAI APIs, which are configured using Flask to enable dynamic trivia generation and real-time interactions. The project environment setup involves installing Unreal Engine and Blender, configuring API keys for Gemini AI and OpenAI, and establishing a workflow where 3D models designed in Blender are exported to Unreal Engine, and trivia data is fetched dynamically via Flask. Development and deployment tools include Visual Studio, VS Code, Unreal Engine, and Blender for asset creation and debugging. Flask is used for backend hosting, while SQLite ensures lightweight and structured data handling. Testing is conducted using unit testing in Python and Unreal Engine debugging tools to validate gameplay mechanics and AI interactions. The selection of these tools is based on their ability to provide high-quality real-time 3D rendering, seamless API integration, minimal database overhead, and AI-driven question generation. Unreal Engine enables immersive heritage exploration, Blender streamlines 3D model creation, Flask facilitates smooth backend operations, and SQLite efficiently manages in-game data, ensuring a well-optimized and interactive gaming experience.

Results

The Heritage Quest system successfully generates AI-driven trivia questions related to Indian heritage, ensuring dynamic and interactive gameplay. The Gemini AI and OpenAI APIs efficiently provide context-aware questions based on player progress, enhancing engagement. The game's Unreal Engine-powered 3D exploration offers smooth navigation and immersive heritage site interactions. Flask and SQLite enable seamless data management, ensuring fast response times for trivia retrieval. Overall, the system delivers an engaging, culturally enriching experience with responsive AI and optimized game mechanics.

Fig 2: State Selection

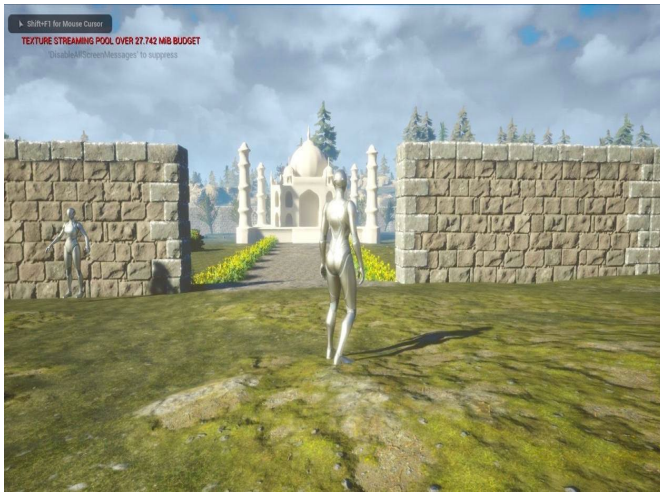

Fig 3: 3D Exploration

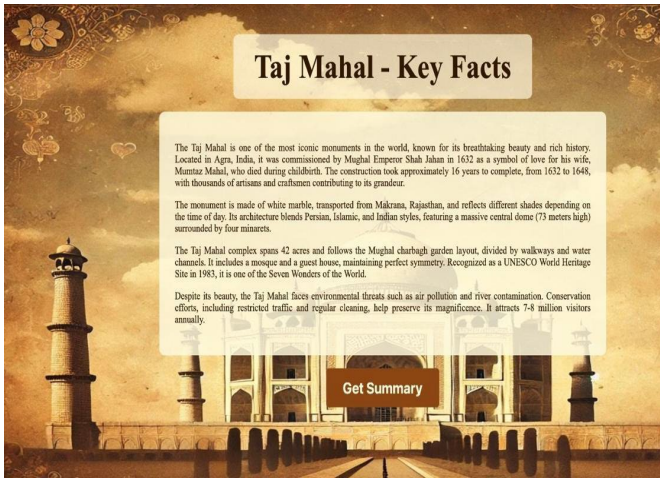

Fig 3: Scroll

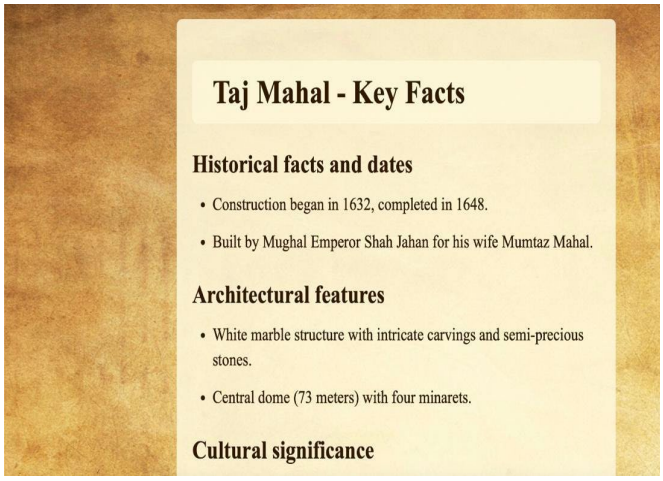

Fig 4: Summarization

Fig 4: Site Exploration

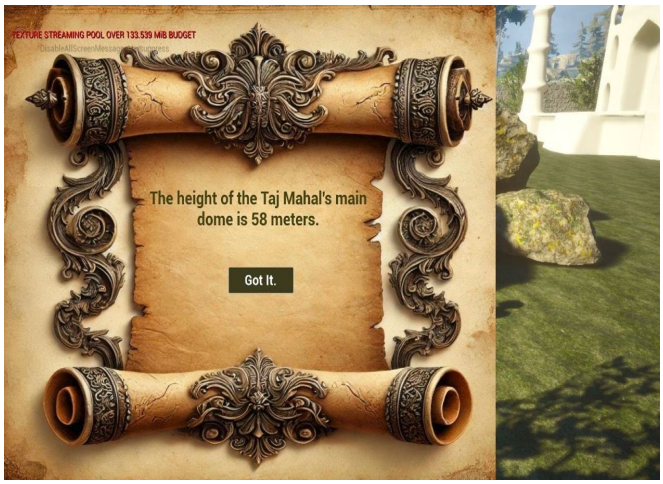

Fig 5: Fun Facts

Fig 6: Quiz Start

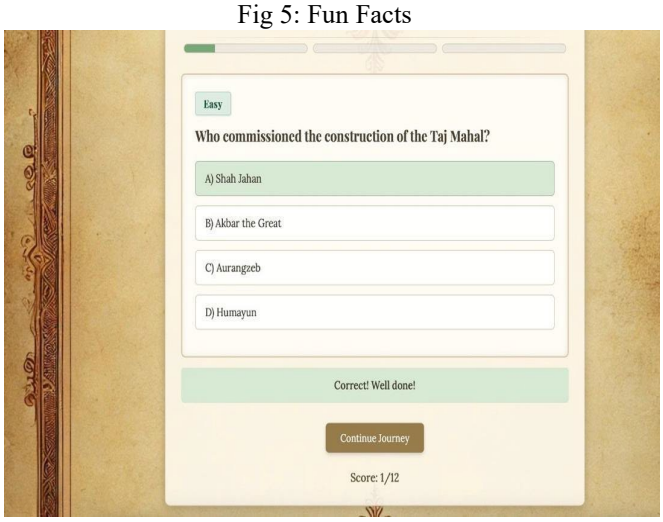

Fig 7: MCQ Quiz

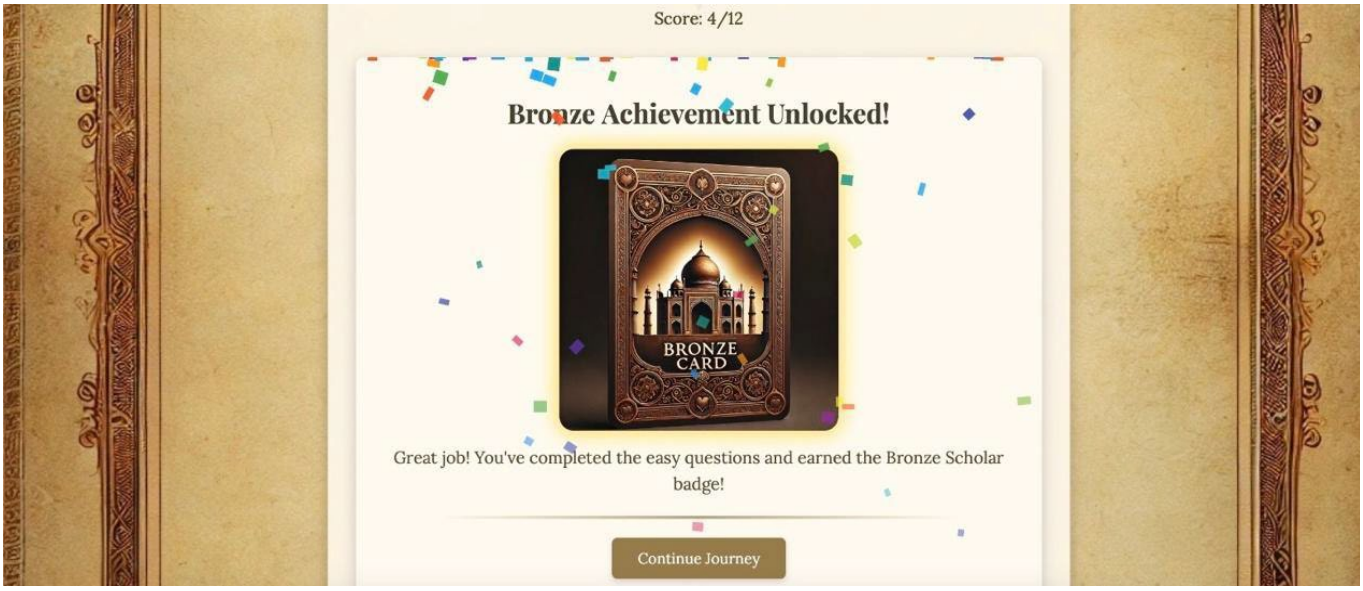

Fig 8: Reward Unlock

Discussion

The results indicate that Heritage Quest provides an engaging and interactive way to explore cultural heritage. The AI-driven trivia system enhances user experience by generating relevant quiz questions. The integration of 3D environments and real-time interactions makes learning more immersive. The system ensures smooth performance with optimized trivia retrieval and adaptive difficulty, keeping users engaged. Overall, Heritage Quest successfully combines technology and cultural education to create an interactive and enjoyable heritage exploration experience.

Conclusion

Heritage Quest is an interactive web-based game designed to provide an engaging cultural learning experience. It features a dynamic map of India where players explore historical sites, uncover details, and interact with artifacts. The system is built using Flask for backend integration and SQLite for efficient data storage, ensuring seamless gameplay. Blender and unreal are used for creating optimized 3D models and environments, enhancing the visual appeal and immersion. By combining interactive exploration with structured progression, Heritage Quest makes heritage learning more accessible and engaging for users.

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