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WebXR Cultural Heritage Tour with Generative AI Characters

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Abstract

This paper presents a project focused on enhancing cultural heritage experiences through a WebXR application by integrating generative AI characters. The application, designed for the Fichtelgebirge region in Upper Franconia, Germany, offers users an immersive digital time travel experience within a museum setting. Structured into six interconnected scenes, each representing a different historical period, the WebXR tour features AI-enhanced historic characters that interactively narrate stories and showcase artifacts. Key elements include animated speaking portraits, interactive 3D models, 360-degree panoramas, and style-transferred historic imagery. The project aims to connect physical museum objects with virtual experiences, enriching the user's engagement with local culture and regional identity. Compatible with multiple devices, including VR headsets, web browsers, and mobile devices, the application ensures broad accessibility and cross-media functionality.

Keywords: *Generative AI, Cultural Heritage, Extended Reality (XR)*

1. Introduction

In recent years, the intersection of cultural heritage and WebXR has opened new avenues for engaging and educational experiences. The integration of AI characters within VR environments offers an enhanced immersive experience, allowing users to interact with historic figures and explore heritage sites in a more dynamic way. This paper outlines the design and implementation of a WebXR tour, developed with the A-Frame framework featuring AI-driven historic characters, detailing the scene structure, key elements, and compatible devices.

The Aframe framework is a powerful and user-friendly framework for creating 3D and VR content on websites. Developed by Mozilla, it is based on HTML, making it easy to create interactive 3D experiences. One of the main benefits for us was, that it is web-based, allowing users to experience VR directly in web browsers without needing extra software or plugins. It also offers easy integration, as developers can seamlessly add 3D and VR content to existing websites using HTML. Aframe is cross-platform, meaning it works on desktops, mobile devices, and VR headsets. Modern web browsers like Google Chrome or Mozilla Firefox support Aframe, making it convenient to use. [IA224]

2. Related Work

During the last years we saw several related works regarding Virtual Tours and AI. The paper "Authentic Interactive Reenactment of Cultural Heritage with 3D Virtual Worlds and AI", the paper explores challenges in rendering 3D heritage objects realistically and presents a method for accurate reflectance distribution estimation using illumination dome images. [BRASC10] The paper "Photorealism and Non-Photorealism in Virtual Heritage Representation", discusses the evolution from accurate reconstructions to non-photorealistic rendering for believable environments, emphasizing realism through interactivity. [RD03] In "Realistic Virtual Humans for Cultural Heritage Applications", the exploration of virtual humans in interactive presentations within cultural heritage settings includes a workflow using motion capture systems and software, validated at Mastic Museum of Chios. [KPP*21]

In "The Potential of 3D Internet in the Cultural Heritage Domain", the challenges of digitizing European cultural heritage and advancements in 3D artifact annotation and integration into Europeana for interactive visualization on standard web browsers are addressed. [SSSF14] "Visual Realism in Digital Heritage", the paper addresses the challenge of realistically rendering 3D objects with diverse materials. It introduces a method for estimating reflectance distribution functions using images from an illumination dome, enabling accurate simulations of object appearances through detailed surface rendering techniques. [Mac18]

The role of virtual museums in creating immersive experiences and advocating for real-time 3D content as standard web media through the X3DOM project in HTML is examined in "X3DOM as Carrier of the Virtual Heritage". [JBG12]

3. The Aframe WebXR Application

Using A-Frame was ideal for our museum storytelling use case. Its capabilities allowed us to create interactive scenes where users engage with historical characters and artifacts. The framework's

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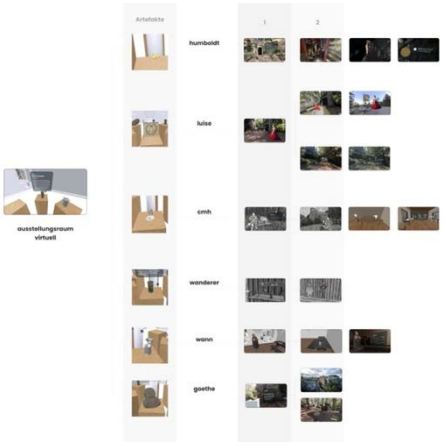

Figure 1: *Storyboard of the sequences in the WebXR Application*

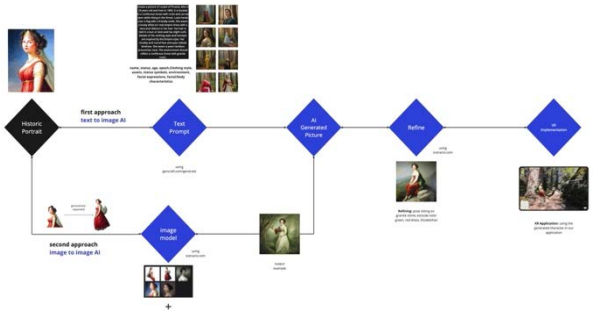

Figure 2: *Our AI pipeline to generate historical characters*

Figure 3: *Generative Portraits to display different poses and holding objects*

flexibility allowed us the integration of 3D-scanned artifacts and historical reconstructions in order to provide both an immersive and educational experience. Visitors can easily access the WebXR experience via URL on smartphones, tablets, or VR headsets without additional installations, ensuring user convenience.

3.1. Scene Structure

The application is structured into six interconnected scenes with several sequences, each representing a different historical period of the Fichtelgebirge in Upper Franconia, Germany. It offers a digital time travel experience to key locations, famous personalities, and thematic identity anchors of the region and tells these stories in an immersive and innovative way. The virtual time travel is also integrated into a real experience space in a regional museum exhibition, through which it connects museum objects with virtual applications, conveying local culture and regional identity.

The VR tour starts in an exhibition room in the museum, depicted as a clean, white space featuring six museum artifacts on pedestals. Users can then interact with these artifacts with a fuse based mouse cursor in the middle of their viewport to travel back to the respective locations and historical periods they represent.

Each of the six scenes features an animated speaking portrait of a historical character from that period, generatively enhanced with AI in order to display different poses or hold objects in their hands. To support and enrich the storytelling, the sequences also include several interactive and animated 3D models, 3D scans of the landscape and 360-degree panoramas of the locations.

3.2. Generated AI Characters

The historical characters were initially available as upper body portraits only and therefore needed to be generatively extended. Through close collaboration with experts in the field of history, the clothing styles from the respective periods were accurately matched to ensure historical consistency. Before integrating, those characters were animated using AI and the Runway Lip Sync [LS2] feature, allowing them to speak and narrate the story of each location and time period. In that manner we developed a pipeline flow, as the creation of historically accurate characters involved a multi-step approach, beginning with the enhancement of the original historic upper body portraits, removing of unwanted background objects, and adding generative details to compensate for missing or obscured features, such as the hair in Queen Luise's original portrait.

An added advantage of having the historical characters narrate their own stories is the enhanced engagement and authenticity it provides. When users hear directly from the characters themselves, it creates a more personal and immersive experience, making history feel more alive and relatable. With this method it captivates the audience and also provides a deeper understanding of the historical context and significance of the events and locations being explored.

3.3. 3D Models

The tour also includes various animated and interactive 3D models of museum artifacts and 3D-scanned landscapes to enhance the immersive experience for users. At some points of the story, the tour also features 3D modeled rooms, like a decorated porcelain factory or an ancient cottage, which were modelled after provided images from the historical period to ensure the historic accuracy. Users can look around and navigate through the rooms with buttons as planes which function as jumping points, providing users a realistic sense of space and presence within the virtual environment.

The museum artifacts were either 3D scanned or manually

Figure 4: *3D scan of a mine tunnel in Goldkronach, Germany*

Figure 5: *Interactive Button in the mining tunnel*

modeled in cases where the scans did not produce satisfactory results or the objects had a too shiny surface. The artifact models were then made interactive inside a model-viewer framework, allowing users to closely examine the historical objects from different angles. Through the model-viewer applications visitors of the museum are able to scale and rotate the model with their hands on a digital information board.

3.4. Interactive Elements

Furthermore the tour features planes as buttons, images and 360 degree panoramas to allow users on one hand to interact and to give a more immersive experience. A fusing based cursor in the middle of the viewport can be used as click mouse. Through which users can then fuse on the buttons to move between scenes, allowing them to access more detailed information about the historical characters and its stories.

Interacting with the artifacts can be done in two ways. The first one is to trigger animations in rotation, scale or position by fusing on nearby buttons or simply by entering the sequence. Also, with handtracking users in a VR device can simply grab an object by using natural gesture interaction with thumb and pointer finger in order to lift it up and to see it even more closely. This is

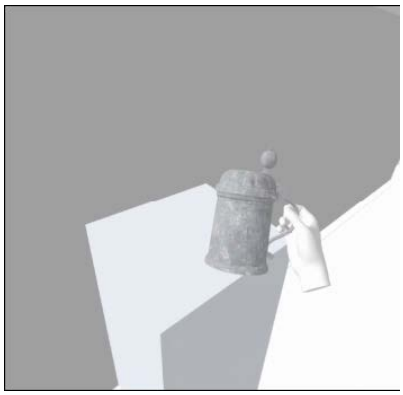

Figure 6: *Natural gesture interaction via hand tracking*

especially interesting for those objects, that have an artistically painted surface.

3.5. Imagery & Style Transfer

360-degree panoramas offer immersive views of the regional landscapes, enriching the Aframe Tour by providing realistic surroundings. Also, by using recent style transfer algorithms, we were able to apply historic imagery of the Fichtelgebirge in Wunsiedel, Germany of the 19th century and apply the styles to nowadays captures of the locations. With that, users can relive the locations through the eyes of the historical styles of that time. The panoramic views not only provide a visual context, but also deepen the user's understanding of the historical environment. The ability to easily compare contemporary and historical visuals by click, enables users to engage with history in a multi-sensory manner, making the learning experience both captivating and more memorable.

By combining these elements, our WebXR tour creates a digitally expanded and engaging museum experience and its exhibits, allowing users to explore and interact with cultural heritage in innovative ways. This immersive approach not only enriches the educational value but also makes the historical narratives more compelling and accessible to a diverse audience.

4. End Devices

This WebXR tour is designed to be compatible with multiple end devices to ensure cross-media accessibility. This supports highend VR headsets such as Meta Quest 3, Oculus Rift, and HTC Vive, providing a fully immersive experience. Additionally, the tour is accessible through standard web browsers, allowing users to experience it without specialized hardware. It is also optimized for mobile devices like phones and tablets, providing flexibility for users to explore the tour on the go. The cross-platform compatibility aspect ensures that a wide audience can access and enjoy our Aframe tour, regardless of the technology they have at hand. By making the application available on various devices, we also aim to democratize the access to cultural heritage and enhance learning opportunities for everyone.

Figure 7: *The historical character 'Queen Luise von Preussen' in a WebXR Application setting*

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