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August 10th ~ 12th, 2026

National University of Mongolia, Ulaanbaatar, Mongolia



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KOREAN INSTITUTE OF SMART MEDIA

NATIONAL UNIVERSITY OF MONGOLIA

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Poster Session 4

Time	August 11 Tuesday (14:00 ~ 15:30)
Room	E-Library of NUM Hallway
Session Chair	Jung-In Choi, Changwon National University

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Best Practices on Constructing a Virtual Art Museum with AI Docent's Agent Approach

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ABSTRACT

Recent advances in generative AI and metaverse technologies have enabled interactive virtual museums that provide personalized exhibition experiences. However, many existing systems still rely on predefined explanations and passive question-answering, without sufficiently reflecting visitors' locations, viewing behavior, inactivity, or exhibition flow. To solve this, we propose an interactive virtual art museum that integrates a behavior-responsive AI docent with experiential content based on major art movements. The system consists of an Unreal Engine-based 3D exhibition space, a Behavior Tree-based docent controller, a voice interaction module combining Speech-to-Text, generative AI, and Text-to-Speech, and interactive content for Impressionism, Pop Art, Abstract Expressionism, and Fauvism. The docent detects visitor entry, artwork-viewing duration, inactivity, and direct questions, then selects suitable guidance behaviors. By combining user questions with artwork identifiers and exhibition context, the system generates context-aware responses. With this approach, we expect to support more active, immersive, and personalized art appreciation within the virtual exhibition environment.

KEYWORDS

Virtual Art Museum, AI Docent, Retrieval-Augmented Generation, Virtual Exhibition

1 INTRODUCTION

Offline art museums preserve and exhibit artworks while providing visitors with artistic and historical knowledge [1]. However, museums operate in limited locations and exhibit for limited periods so that visitors may face geographical and time constraints [2]. Crowded exhibitions can also make it difficult for visitors to view artworks carefully. In addition, museums often have a limited number of docents and fixed service hours. As a result, they cannot easily provide personalized guidance based on each visitor's interests and viewing behavior.

Virtual museums based on virtual reality and metaverse technologies can reduce these physical limitations [1]. Visitors can enter a 3D exhibition space without time or location limits, explore the environment, and interact with artworks and virtual objects [3]. However, many existing virtual exhibitions mainly reproduce physical exhibition spaces and artworks in a digital environment [4]. They often provide only predefined text or audio explanations. Therefore, they still deliver information in a one-way manner, and visitors remain passive receivers of information.

A previous study proposed an AI docent response mechanism that uses generative AI to answer natural language questions about artworks [5]. This approach improves fixed explanation systems, but it works only after the visitor asks a question. In a real museum, a docent does more than answer questions. The docent should recognize which artwork a visitor is viewing, how long the visitor stays in front of the artwork, and whether the visitor has stopped interacting with the exhibition. Based on this information, the docent should provide suitable guidance.

To address these limitations, we extend the previous natural language-based AI docent response mechanism into a virtual docent agent that recognizes visitor behavior and provides active guidance. In the proposed system, generative AI serves as a submodule that generates answers to artwork-related questions. A Behavior Tree controls the docent's movement, visitor tracking, artwork explanations, exhibition guidance, and interaction timing. Therefore, the AI docent recognizes when a visitor enters the exhibition space, how long the visitor looks at an artwork, whether the visitor remains inactive, and whether the visitor asks a direct question. It then selects and performs appropriate guidance actions.

We also implemented experiential interactions based on the visual and expressive features of Impressionism, Pop Art, Abstract

Expressionism, and Fauvism. Visitors can interact with 3D objects, change colors and shapes, and experience music and animations. These activities help visitors directly experience the visual and sensory features of each art movement. The proposed system provides behavior-based docent guidance and context-aware voice responses while supporting active participation through interactive exhibition content.

Chapter 2 reviews previous studies on virtual museums, generative AI-based docents, and Behavior Tree-based virtual agents. Chapter 3 presents the overall structure of Art Venture and the design of the AI docent. Chapter 4 describes the implementation and application of Art Venture using Unreal Engine. Finally, we finish the paper with the results and discuss future work.

2 RELATED WORKS

2.1 Virtual Art Museums and Interactive Exhibitions

Virtual art museums use web, virtual reality, and metaverse technologies to provide exhibition spaces and artworks in digital environments. These systems allow visitors to view exhibitions without time or location limits. They can also provide interactions such as moving around artworks, enlarging images, and controlling virtual objects. Shikhri et al. analyzed 40 online museum tours and found discrepancies between users' expected navigation methods and the systems' actual behavior [6]. Their results show that reproducing a physical museum in a virtual space does not automatically provide an intuitive and immersive experience. Fig. 1 is a Virtual Art Museum example.

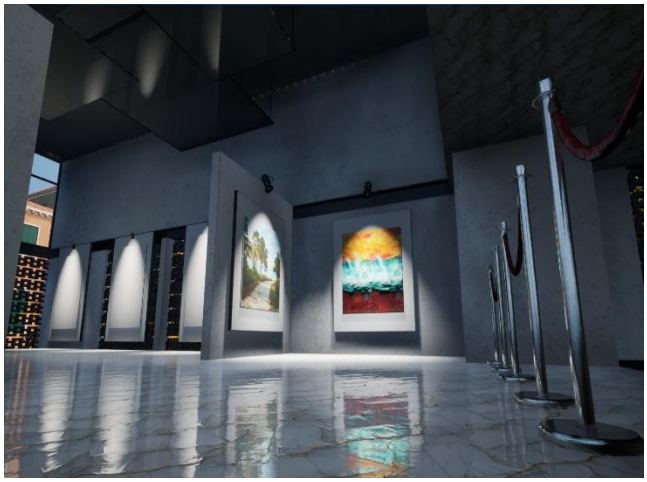


Figure 1. Virtual Art Museums

Many existing virtual museums reproduce museum spaces and artworks and provide predefined explanations or fixed viewing routes. However, these systems cannot easily change their guidance according to visitors' interests and behavior. Therefore, they often limit visitors to passive information receivers. Virtual museums should combine artwork explanations with spatial navigation, visual feedback, and interactive activities.

2.2 Generative AI-Based Docents

Kopp et al. developed a conversational museum guide in which a virtual character named Max communicated with visitors and provided exhibition information through natural language [7]. Recent advances in large language models enable AI docents to generate new explanations based on visitors' questions rather than selecting only predefined answers. Trichopoulos et al. used GPT-4 with contextual information, such as exhibition location, viewing time, and user preferences, to provide personalized artwork recommendations [8].

Wang et al. developed VirtuWander, which analyzes visitors' voice input and uses a large language model to provide avatar responses, speech, and visual feedback in a virtual museum [9]. Our previous study also proposed a mechanism whereby generative AI generates docent responses from natural-language sentences and artwork information [10]. These studies show the potential of flexible explanations and personalized guidance. However, most systems respond only after visitors ask a question or give a command. Therefore, an active docent should also recognize artwork-viewing time and visitor inactivity and provide guidance even when the visitor does not ask a question.

2.3 Behavior Tree-Based Virtual Agents

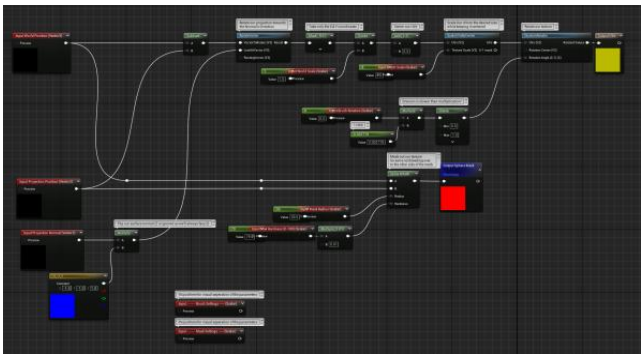


Figure 2: Behavior Tree-Based Virtual Agents

A Behavior Tree organizes the actions of autonomous agents, such as game NPCs and robots, in a hierarchical structure. It commonly includes Sequence nodes that execute actions in order, Selector nodes that choose an available action, Condition nodes that check environmental states, and Action nodes that perform actual behaviors. Compared with a Finite State Machine, as shown in Fig. 2, a Behavior Tree makes it easier to manage complex behavior transitions, add new conditions and actions, and reuse existing behaviors [6].

We use a Behavior Tree to control the AI docent's behavior. Condition nodes check whether a visitor enters the exhibition space, views an artwork for a specific period, remains inactive, or asks a question. Selector nodes then choose an appropriate behavior, such as explaining an artwork, guiding the visitor, answering a voice question, or walking around the exhibition space. In this structure, generative AI produces answers to artwork-related questions, while

the Behavior Tree controls the movement and behavior flow of the docent.

3 Art Venture System Design

3.1 System Architecture

Art Venture consists of a main menu, a common lobby, four themed exhibition spaces, and an AI docent. When a user launches the program and begins viewing, the system provides access to the common lobby. From the lobby, visitors can select one of the following themes—Impressionism, Pop Art, Abstract Expressionism, or Fauvism—to proceed to the corresponding theme level.

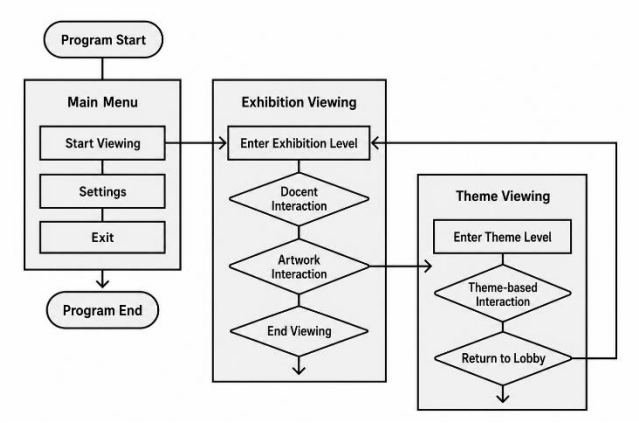


Figure 4. Art Venture System Level Design

Fig. 3 is a flowchart of the Art Venture System. In each theme level, visitors can view artworks, interact with the AI docent, and engage in theme-specific experiences. Once the experience is complete, visitors can return to the lobby to select a different theme. By separating the lobby and theme levels in this manner, each exhibition content is managed independently, and changes to the existing system are minimized when adding new themes.

3.2 Art Venture Class Structure

In Fig. 4, Art Venture consists of key classes including the AI Docent, Docent Controller, Exhibition Space Movement Object, and Painting System. The 'AIDocent' class represents a virtual docent character and manages the artwork viewed by visitors, viewing times, and inactivity times. The 'DocentController' class connects to the AI Docent, executes the Behavior Tree, and controls the docent's movement and behavior.

The 'TeleportableObject' class enables visitors to move between the lobby and each theme level and handles exhibition space transitions through a common interaction interface. The 'MeshPaintSystem' class is responsible for the painting functions of the Fauvism theme and manages the material and UV information of the meshes to be painted. This separation of classes enhances the system's maintainability and scalability by independently managing functions for docent behavior, spatial movement, and artwork interaction.

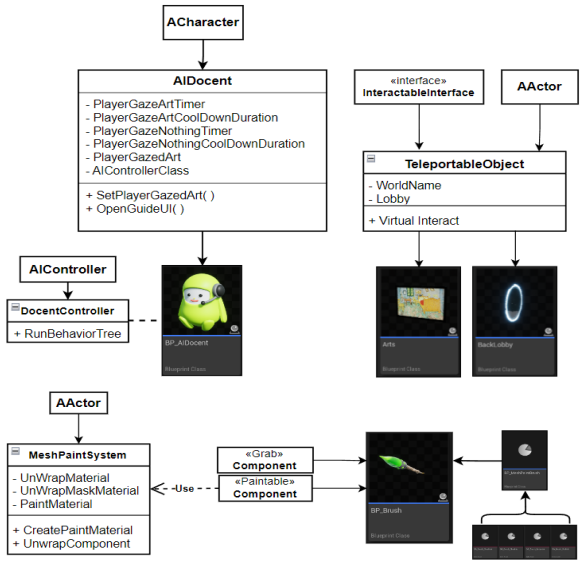


Figure 3. Art Venture Design with Class Diagram

4 Art Venture System Design

4.1 Virtual Exhibition Space

We implemented Art Venture's 3D virtual art museum using Unreal Engine. The exhibition space consists of a common lobby and four themed levels covering Impressionism, Pop Art, Abstract Expressionism, and Fauvism. Visitors select their desired art movement in the lobby and engage in artwork viewing and experiential interactions within each themed space.

The AI docent circulates through the exhibition space, monitoring visitors' locations and behavior. When a visitor meets specific conditions, the Behavior Tree selects an appropriate action, and if a question arises, a generative AI-based voice response module is executed. This is a clear indication that both the Py and Co sub-elements are in a single domain state where Py and Co magnetizations are all oriented with their magnetic moment along the chain and field direction.

4.2 Pop Art Theme Interaction

The Pop Art theme, which is in Fig.5, is designed to allow visitors to experience the characteristics of Pop Art, which transforms popular culture and everyday images into artistic expressions. When visitors interact with artworks or exhibition objects, the system applies selected visual elements to the dynamic materials of the exhibition objects. This allows visitors to immediately observe how color and image representations affect the impression of space and the artwork.

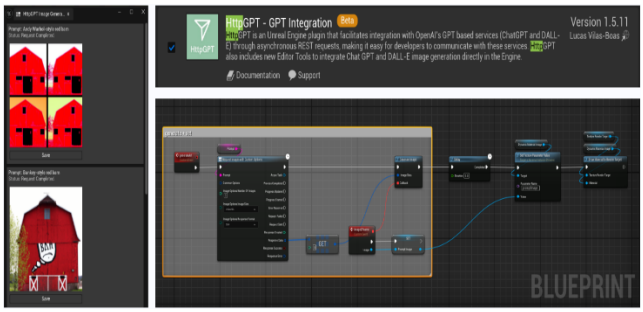


Figure 5. Pop Art Theme that is applied to Dynamic Material

In Unreal Engine, Dynamic Material Instances were used to modify the active object's texture and material values . Consequently, the system reflects visitors' input in the exhibition space in real time without reloading a new level. This feature is distinct from the function for creating new artworks using generative AI, which is used exclusively for the AI docent's Q&A about the artworks.

4.3 Fauvism Theme Interaction



Figure 6. The Fauvism Theme in Art Venture

The Fauvism theme in Fig. 6 is implemented to allow visitors to directly experience the characteristics of the art movement, such as intense colors and free expression. Visitors can use a virtual brush to paint desired colors onto 3D objects in the exhibition space. The system identifies the brush position and the target mesh, calculates UV coordinates corresponding to collision points, and applies the color to the material.

The painting function consists of a MeshPaintSystem and paintable components. The MeshPaintSystem converts the target mesh's material into a paintable dynamic material and records the color selected by the visitor into a texture. Through this, visitors can move beyond simply viewing fixed artworks and experience the expressive style of Fauvism by directly changing the colors of the space.

4.4 AI Docent Behavior Tree

The AI docent selects actions such as exhibition guidance, artwork descriptions, viewing advice, Q&A, and exhibition tours based on the visitor's behavior. We implemented these actions using Unreal Engine's Behavior Tree.

The Behavior Tree sequentially checks whether there is direct interaction with the visitor, the time spent gazing at artworks, periods of inactivity, and whether the visitor has entered the exhibition hall. If a condition is met, the corresponding action node is executed; if no condition is met, the docent tours the exhibition space using the default behavior. Table 1 shows the behavioral guidelines for the AI docent.

Table 1: Visitor Behavior

Atm	MS-CG
Enters the exhibition space	Approaches the visitor, gives a welcome greeting, and introduces the exhibition.
Looks at a specific artwork for more than five seconds	Moves toward the artwork and provides an explanation
Does not view any artwork for three minutes	Approaches the visitor and suggests the next viewing activity
Directly interacts with the docent.	Recognizes the visitor’s voice question and provides an
Does not meet any of the above conditions	Autonomously walks around the exhibition space

5 CONCLUSIONS

We designed and implemented **Art Venture**, a virtual art museum that combines a behavior-responsive AI docent with interactive exhibition content. Unlike existing AI docents that mainly answer pre-defined user questions, our system recognizes visitor entry, artwork-viewing time, inactivity, and direct questions. A Behavior Tree controls the docent’s movement, visitor tracking, artwork explanations, and interaction timing, while generative AI generates answers to artwork-related voice questions. We also implemented interactive experiences based on Impressionism, Pop Art, Abstract Expressionism, and Fauvism through 3D object manipulation, color changes, music, animation, and painting. These functions allow visitors to actively experience the features of each art movement instead of only receiving predefined explanations. Separating docent behavior control from response generation also improves the stability of the virtual agent and supports context-aware guidance.

This focuses on functional implementation, so we did not conduct quantitative user evaluations. Future work will compare the proposed system with fixed-type docents using artwork

comprehension, immersion, usability, and task success rates. We will also study personalized guidance, multimodal behavior recognition, and retrieval-augmented generation using curator-verified artwork data.

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