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Optimizing Virtual Culinary Tours Using Character-based Interaction and Finite State Machine (FSM)

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Abstract

This research focuses on the development of a Virtual Tour application utilizing Finite State Machine (FSM) to enhance the interaction of a Non-Playable Character (NPC) as a tour guide in a 3D virtual environment. The primary issue addressed is the significant impact of the COVID-19 pandemic on the tourism industry, which led to travel restrictions and limited opportunities for visitors to explore tourist destinations physically. The aim of the study is to create a virtual tourism experience as an alternative solution, enabling users to explore historical sites like Pasar Lama Tangerang remotely through Google Cardboard VR. To achieve this, the NPC's behavior is controlled using FSM, allowing the character to transition between states—idle, walking, and talking—based on user interactions. Data was collected through user testing with a Likert scale questionnaire, evaluating user satisfaction and the effectiveness of the FSM method. The results revealed a 74.35% positive user rating, categorized as Good, demonstrating the potential of FSM to provide an interactive, engaging, and educational virtual tour experience. These findings highlight the effectiveness of FSM in creating a dynamic and user-responsive virtual tour, offering significant benefits to the tourism sector by providing an innovative, accessible, and immersive way for potential visitors to explore destinations during travel restrictions. This research contributes to the growing field of e-tourism, showcasing the potential of virtual reality and FSM to transform the tourism industry in times of crisis.

I. INTRODUCTION

The development of technology is an unstoppable challenge in human life. In this context, technological advancement must be harnessed intelligently, becoming a tool for individuals to develop their potential. This proves that technological progress is an advancement that can organize human life, making it easier and more cohesive [1]. One form of technology utilization is in the multimedia field, such as the creation, processing, and presentation of creative and engaging multimedia content. This area is frequently used to convey information, media simulations, and advertisements, which are particularly relevant in the tourism industry, an industry that was severely impacted by global economic challenges.

The global economic downturn significantly altered various sectors, prompting the implementation of policies such as physical distancing, social restrictions, and travel bans, which were viewed as effective measures to prevent further economic disruption. Local governments made extensive efforts to guide the public in reducing outdoor activities, both locally and nationally.

Many sectors in the country were negatively affected by the economic crisis, but the tourism sector experienced some of the most noticeable consequences. For example, the total losses for hotels and restaurants in Indonesia, according to the Chairman of the Indonesian Hotel and Restaurant Association (PHRI), Hariyadi Sukamdani, amounted to IDR 70 trillion. More than 2,000 hotels and 8,000 restaurants had to close and halt their operations. Many employees were furloughed or placed on unpaid leave while waiting for an increase in demand[2]. As a result, the global tourism industry has attempted to adopt virtual-based tourism promotion

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systems to provide a different user experience while offering a preview of the products being sold, which in turn encourages purchase intentions and visitation from potential customers [3]. his alternative system can be developed into a concept known as Virtual Tour or eTourism, which integrates Information and Communication Technology (ICT) with the tourism industry. The advantage of eTourism is that it allows people to quickly and easily access information about tourist destinations [4].

The eTourism concept has been used as an alternative means to help the tourism industry survive and recover from hardships. Transitioning to digital media and creating new digital innovations can be considered an effective strategy to adapt to the ongoing technological developments, resulting in a method called Virtual Tour or eTourism, an activity conducted in the New Normal era [5]. E-Tourism is derived from "electronic tourism," representing the integration of ICT advancements with the tourism sector. One of the benefits of eTourism is that the public can easily and quickly access information about tourist attractions in a particular area [4].

eTourism utilizes multimedia elements such as sound effects, music, narration, and text. A key component of eTourism is panoramic images that present wide, uninterrupted views. Panorama photography is a technique using equipment or software to capture images with an extended field of view [4]. eTourism with panoramic photography is particularly appealing because it provides visitors with a 360-degree view by altering the perspective of the photo or video.

Virtual Reality (VR) is one of the multimedia technology applications that excels in representing objects in such a way that the visualization can be viewed from every angle in three-dimensional (3D) form. Virtual Reality is akin to dreaming while awake, offering experiences in a magical world, like those in cartoons, or transporting users to distant places on Earth or even the universe [6].

Virtual tours are increasingly attractive due to their ability to provide in-depth and personal experiences to a wider, more diverse audience. However, the VR headsets required for this experience are relatively expensive. As an affordable alternative to costly VR headsets, Google Cardboard has emerged as a low-cost device, equipped with lenses that allow a smartphone to transform into a VR viewer [7].

Google Cardboard is user-friendly, practical, and offers a simple, cost-effective virtual reality platform that works with compatible VR apps on smartphones to create virtual environments. Google announced in November 2019 that its software development kit (SDK) would be made open-source. However, Google Store ceased selling Cardboard in 2021 [8]. Google Cardboard has been used in education to create desired virtual environments for 3D graphics. The immersive learning experience and interaction have been shown to positively impact attitudes and engagement in various educational contexts [9]. It is important to note that lens quality plays a significant role in the user experience, and care should be taken to procure only high-quality cardboard with lenses tested through trials with different vendors.

This study aims to build a simulation environment based on real-world tourist attractions, incorporating NPCs (Non-Playable Characters) that act as tour guides to provide various pieces of information about the tourism area and highlight popular spots for visitors. The tourist site chosen for the simulation is the Kuliner Pasar Lama area in Tangerang. AI (Artificial Intelligence) using the FSM (Finite State Machine) method will be applied to the NPCs so they can follow or guide the user..

The method to be used is the Finite State Machine (FSM) model. FSM is a computational model used to simulate a sequence of logic or represent an execution sequence and state transitions. Typically, FSM is used to simplify code for characters, especially for NPCs that consistently move under certain conditions [10]. FSM can receive input and produce output with a finite set of states [11]. This method will be applied to build NPC characters and define how these characters react.

II. RELATED WORKS/LITERATURE REVIEW

The Finite State Machine (FSM) method is an algorithm that encompasses the behavior of an agent. FSM itself has four main components: state, event, transition, and action. These four elements are interconnected, with transitions changing the state condition into a new condition [12]. FSM is a mathematical model consisting of states and transitions. The states in the FSM model represent the current condition of the system, and transitions occur between states based on a set of actions and system responses [13]. The development of FSM is used as a strategy to determine 3D animation actions for how characters react or decide actions based on specific situations or events [14].

Finite State Machines are easy to implement or hard-code and offer the flexibility of an algorithm that allows for various implementation approaches. However, FSM uses many method calls within its algorithm, which results in slower processor performance. FSM is difficult to maintain because the code for this algorithm can become very large, making it appear cluttered and unclear. Programmers also need to create behaviors for each character or agent, which requires more time when compiling the program [12].

FSM consists of a series of states that determine decision-making. Each state can transition to another state if the specified conditions are met. States are interconnected through transitions between states, and each subsequent transition leads to the target state. The initial state always functions as the starting point, while the input event or

action acts as a trigger that guides rule execution. If the conditions and requirements are met, a transition from one state to the next occurs according to the specified conditions.

FSM tracks the set of existing states, then inputs are directed to each state, with a fixed series of transitions. Each transition can be implemented with the appropriate conditions. In each frame, the FSM update function is used. This checks for any transition changes triggered by input. It then lists the actions of the active state. If the transition has found the intended action, the transition stops [15].

The application of logic to NPC characters begins with standing idle and waiting for the player in an idle state. When the NPC starts a dialog to interact with the player, the character enters a talking state. When the player is free to explore, the character enters a walking state to follow the player around the tourist site.

The design of a virtual zoo with the help of Google Cardboard was carried out. This design method involved eight different animals, collecting 3D animation models of animals along with 360-degree video and their vocal expressions that mimic natural sounds. The results of the evaluation and analysis of this study showed that this virtual zoo could be very helpful for people with disabilities and that the application is quite user-friendly [16].

The concept of Virtual Tour is the utilization of information and communication technology to enhance efficiency in the tourism sector, offering various tourism services to customers and making tourism marketing more accessible through Telematics. The popularity of Virtual Tours among tourism managers is due to the relatively low financial investment required. Virtual tours offer visitors a set of tools that facilitate learning and enable the intangible and real qualities of tourist sites to be communicated [17].

Virtual Tourism has various forms that can be outlined through several mediums [18], one of which is in the form of Virtual Reality. Virtual Reality is an interaction between humans and a simulated environment created using computer graphics technology and Artificial Intelligence (AI). The word "Virtual" is interpreted as imagination, and "Reality" is understood as actuality.

III. METHODS

A. Multimedia Development Methodology

The Multimedia Development Methodology is used to design, develop, and create multimedia products such as applications, presentations, or interactive content. Several commonly used multimedia development methods in this research are as follows:

a. **Requirements Analysis**
This stage involves identifying and understanding the audience's needs and the goals of the multimedia project. Research and analysis are necessary to determine what is expected from the eTourism product and to identify its target audience. In this study, the target audience is visitors to Pasar Lama Tangerang and individuals interested in culinary areas.

b. Design
This stage focuses on planning the design based on the results of the requirements analysis. The design includes planning the layout, information structure, interaction, and aesthetics of the eTourism application for Pasar Lama Tangerang.

c. Material Collection
At this stage, all materials to be used in the multimedia project are collected, such as text, images, sounds, videos, animations, and so on. These materials are then processed and prepared to be incorporated into the multimedia product. The material collection process in this research was carried out through field surveys in Pasar Lama Tangerang, capturing images of the location and the products sold to map out the relevant information.

d. Creation
This stage involves the creation of content, including graphic design, animation, video creation, sound recording, and more. In this research, the creation process is carried out in the form of 3D animations.

e. Testing
The testing stage involves trying out the final product to ensure that all functions work properly and meet expectations.

B. Finite State Machine (FSM) Method

In this research, the Finite State Machine (FSM) Method is used to control the behavior of NPC characters and incorporate animations to make interactions with users feel more natural and dynamic. FSM is a model that has a limited number of states at any given time and can operate based on inputs received. Transitions between states result in specific outputs or actions [19]. This method offers advantages in its simplicity in computation, ease of understanding, and implementation. Using FSM allows NPC characters to interact with players in a more friendly and responsive manner [20].

The application of FSM in this eTourism project focuses on controlling the NPC Tour Guide, which is determined by various conditions. FSM is applied to control the animation of the tour guide character. Below is the FSM design for the tour guide character as shown in Figure 1.

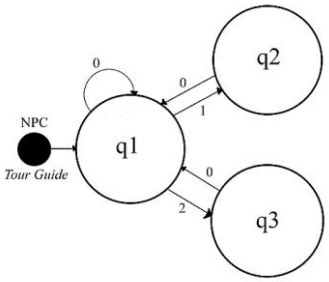

Fig 1. FSM Diagram Design on Tour Guide Character

Description:

Q = {q1, q2, q3, q1} (set of states for the tour guide character)
Σ = {0, 1, 2} (set of input symbols)
S = q1 (initial or idle state)
Δ = {((q1, 0)0), ((q1, 1) q2, ((q1, 2)q3, ((q2, 0) q1), ((q3, 0)q1)}

Q is the set of states that consist of actions performed by the tour guide character. q1 represents the idle state, q2 represents the walking state, and q3 represents the talking state. Σ is the set of input symbols. In this case, the distance or parameter serves as the input symbol to be used. The input symbols are 0, 1, and 2. S denotes the initial state, which is q1 (idle state).

0 = no conditions.
1 = if the player's distance >= 4
2 = if the player is within the trigger box.

The character's initial state runs the idle animation. As long as there are no conditions, the initial state will continue to loop. In the first session, when the player approaches the character and enters the available trigger box (which is not visible to the player), the character will enter the talking state, and after the dialog ends, it will return to the initial state. When the player starts walking and enters the second session, the character will begin to follow the player. If the player's distance is >= 4 from the character, the character will enter the walking state to follow the player. The tour guide character's FSM does not have an end state, so the states will continue to loop until the player finishes the program.

IV. RESULTS

The development of a virtual tour system for the Pasar Lama area of Tangerang aims to create an immersive and engaging experience for users. A key challenge in virtual tourism applications is animating interactive characters, specifically tour guides, to respond realistically to the player's actions. This study addresses the problem of static character behavior in traditional virtual tours by implementing a Finite State Machine (FSM) method to enable dynamic character states. The FSM method allows the tour guide character to respond with appropriate movements and actions based on the player's proximity and interactions, improving the overall user experience. The character operates within three states: idle, walking, and talking, which are triggered by specific conditions during the tour.

The following describes the system's flow, including the functionality of the FSM model and the results of application testing.

A. Application Overview

Upon opening the application, players immediately enter Virtual Reality (VR) mode and are greeted with an informational screen about the application, including credits and instructions. After confirming by selecting "OK", the screen disappears, and players are directed to the main menu, as shown in Figure 2.

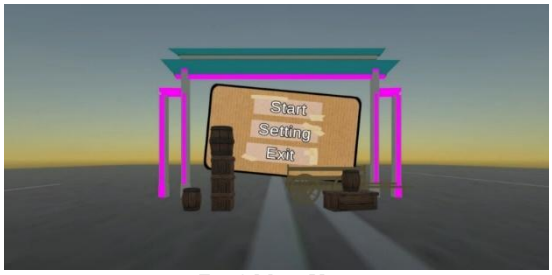

Fig. 2 Menu View

Figure 2 shows the main menu of the Pasar Lama Virtual Tour application. The menu consists of three primary buttons: the Start Button, the Settings Button, and the Exit Button. The Start Button is used to initiate the application and begin the virtual tour of Pasar Lama Tangerang. When clicked, it leads the player to the next screen where the virtual tour commences. The Settings Button allows players to access the audio settings, enabling them to toggle the background music (BGM) according to their preferences. Lastly, the Exit Button provides the option to exit the application entirely. Once the player selects "Start," they are presented with a second informational screen introducing the Pasar Lama Virtual Tour. After acknowledging the screen by pressing "OK," the player is placed into the 3D virtual environment. Here, they are introduced to the tour guide character, who initially appears in the idle state, waiting to interact with the player as they explore the virtual space.

B. Tour Guide Behavior and Interaction

As the player approaches the tour guide character, the character enters the talking state and initiates a dialogue, as shown in Figure 3. After the dialogue ends, the player is free to explore the virtual environment. When the player moves, the character transitions to the walking state, following the player while maintaining an appropriate distance. This dynamic interaction is a direct result of applying the FSM model to the character's behavior.
If the player approaches a stall, the character pauses its movement, entering the talking state again. The character then provides information about the products available, as shown in Figure 4. Three options appear during the dialogue:

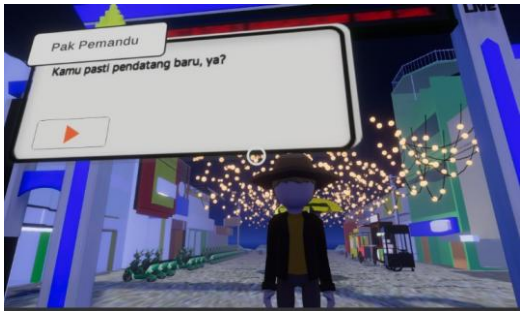

Fig. 3 Character Dialogue Display

Fig 4. The dialogue display when approaching the food vendor

The interaction options presented to the player during the tour include three key buttons: "View Menu!", "More Information!", and "See Something Else". The "View Menu!" button displays an image-based menu of the products available in the virtual tour. The "More Information!" button provides detailed information about the product, such as its opening hours, available delivery options, and relevant social media links for further updates. Lastly, the "See Something Else" button closes the current dialogue and allows the player to continue exploring other areas or products. This cycle of exploration and interaction repeats as the player moves through the virtual environment.

When the player decides to conclude their tour, they can approach the gate, which triggers a final dialogue, as shown in Figure 5. At this point, the player is presented with two options: "Finished! Thank you for the tour!",

which ends the interaction with a closing message and exits the application, or "Not Finished! Keep Exploring!", which allows the player to continue exploring but prevents them from exiting the application until they select the "Finished!" option. This structure ensures that players can navigate the experience at their own pace while providing clear exit points for concluding the tour.

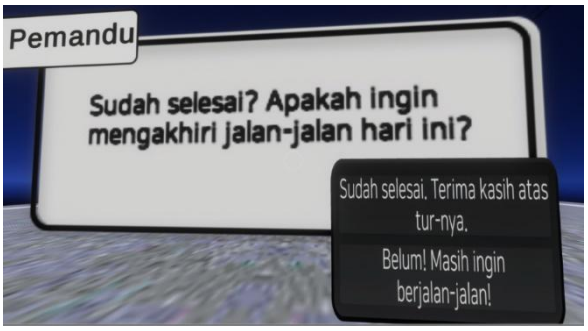

Fig. 5 The dialogue display when the player wants to exit the virtual tour area

C. Testing the FSM Method for the Tour Guide Character

The application testing was conducted by gathering user feedback through a questionnaire. The responses were then analyzed using the Likert scale method, with value intervals of 20 (Strongly Disagree), 40 (Disagree), 60 (Neutral), 80 (Agree), and 100 (Strongly Agree). The scores were multiplied by the total number of respondents, which was 31, resulting in ideal scores of 620 (Strongly Disagree), 1240 (Disagree), 1860 (Neutral), 2480 (Agree), and 3100 (Strongly Agree). The table below Table 1 presents the results of the FSM method testing, outlining the conditions for each state of the tour guide character, such as "Idle," "Walking," and "Talking," and providing a description of their expected behavior in the application. The table will also present the total ideal score for each question based on the user feedback.

TABLE 1
RESULTS OF FSM METHOD TESTING

State	CONDITION	Description
Idle	No conditions	As expected, the character remains idle when no interaction occurs.
Walking	Player distance >= 4 meters	The character follows the player when the distance reaches 4 meters.
Talking	Player enters trigger box	The character enters the talking state when the player approaches a specific trigger zone.

D. Application Testing and User Feedback

To evaluate the effectiveness of the application, a user questionnaire was administered, and the responses were analyzed using a Likert scale. The following table presents the results, where 20 represents "Strongly Disagree," 40 represents "Disagree," 60 represents "Neutral," 80 represents "Agree," and 100 represents "Strongly Agree." The total number of respondents was 31, resulting in an ideal total score range from 620 (Strongly Disagree) to 3100 (Strongly Agree).

TABLE 2
LIKERT SCALE QUESTIONNAIRE RESULTS

No	QUESTION	Response					Result	Percentage
		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree		
1.	Did you enjoy your experience with this e-Tourism application?	0	0	180	480	2200	2860	92.26 %
2.	Were the available features sufficient?	0	120	480	1360	300	2260	72.9 %
3.	Did the NPC's behavior not interfere with the experience?	0	80	780	720	700	2280	73.55 %
4.	Was the NPC's behavior appropriate for its role as a Tour Guide?	20	240	480	1040	300	2080	67.1%
5.	What is your opinion on the 3D model of Pasar Lama Tangerang?	0	160	900	560	500	2120	28.39 %
6.	Was the information about the products clear?	0	40	300	480	1900	2720	87.74 %
7.	Did the application make it easier to explore Pasar Lama Tangerang?	0	80	780	880	500	2240	72.26 %
8.	Was the application easy to use?	20	400	660	400	400	1880	60.65 %

Based on the results from Table 2, the overall score was calculated by averaging the scores from all the questions, which resulted in a total score of 2305. This score was then converted into a percentage by comparing it to the maximum possible score, yielding 74.35%. This indicates that the overall response was positive, with the score falling into the "Agree" or "Good" category.

The results from the assessment demonstrate that the application has successfully addressed the issues raised in the introduction. Specifically, the high overall score of 74.35% indicates that the virtual tour system was well-received by users. Participants expressed satisfaction with the interactive features, including the behavior of the tour guide character and the overall navigation experience within the Pasar Lama Tangerang. This suggests that the use of the FSM method in controlling the tour guide's movements and interactions, as well as the design of the e-Tourism platform, contributed effectively to creating an engaging and user-friendly experience. Consequently, the application appears to fulfill its objective of providing an informative and enjoyable virtual tour for users, aligning with the initial goals outlined in the introduction.

V. DISCUSSION

This study presents a novel solution to a pressing challenge in the tourism industry by integrating multimedia technology and artificial intelligence (AI) to enhance the virtual tourism experience. The application of Finite State Machine (FSM) methodology to control the behavior of non-playable characters (NPCs) significantly improves interactivity within virtual tours. Unlike traditional virtual tours, which often feature static, non-responsive characters, the FSM model enables NPCs to dynamically adjust their actions based on user proximity and movement. This creates a more engaging and immersive experience, where users feel more actively involved in the tour, leading to higher levels of user satisfaction and deeper engagement.

Furthermore, the use of affordable virtual reality (VR) technologies, such as Google Cardboard, expands the accessibility of the virtual tour experience. By reducing the cost barriers typically associated with high-end VR setups, this solution allows a broader audience to experience immersive virtual tourism. This cost-effective approach ensures that virtual tours are not limited to well-funded institutions or niche markets, but can instead reach a wide variety of users, thereby democratizing access to virtual tourism experiences. This is particularly significant in an era where the accessibility and scalability of digital experiences are crucial to expanding tourism engagement.

The findings of this study highlight the potential of multimedia and AI to transform the tourism industry by offering innovative ways to engage potential visitors. The FSM-driven, interactive virtual tour model, combined with affordable VR technology, offers a compelling alternative to traditional tourism, making it possible for users to explore destinations remotely in an engaging and personalized manner. This approach opens up new avenues for promoting tourism and providing enriched, dynamic experiences that can be tailored to individual preferences, thus presenting significant opportunities for the future of virtual tourism.

VI. CONCLUSIONS

This study demonstrates the potential of integrating multimedia technology and artificial intelligence (AI) to enhance virtual tourism experiences. By employing the Finite State Machine (FSM) methodology, this research effectively addresses the limitations of static character behavior in traditional virtual tours, offering a more interactive and engaging user experience. The use of affordable virtual reality (VR) technology, such as Google Cardboard, further broadens the accessibility of virtual tours, making them more accessible to a wider audience. The results show that combining FSM-controlled NPC behavior with cost-effective VR solutions can significantly improve the immersion and realism of virtual tourism, offering a practical and innovative alternative to traditional tourism models.

However, there are areas for improvement in further studies. While this research successfully demonstrates the feasibility of FSM-based interactivity and affordable VR, future work could explore more sophisticated AI algorithms and advanced VR hardware to enhance the realism and personalization of the virtual tour experience. Additionally, future research should consider expanding the scope of virtual destinations and incorporating more diverse user profiles to assess the scalability and adaptability of the proposed system in various contexts.

The findings of this research have important applications in the tourism industry, particularly in enhancing remote visitor engagement and providing alternative ways to promote tourism during periods of economic downturns. However, the study is limited by the simplicity of the FSM model and the use of basic VR technology. Future studies could focus on refining these elements to further optimize the virtual tour experience. Based on these results, it is recommended that tourism stakeholders invest in the development of more advanced AI-driven virtual tour systems that can cater to diverse user preferences and provide personalized, interactive experiences.

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