Virtual Reality Home as Reminiscence Therapy for Dementia

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Abstract. In the Philippines, there is a high dementia prevalence among older adults. Local treatments are mostly limited to drug medication and home care, but there have been non-pharmacological advances that use VR software for dementia therapy. However, these have only been partially implemented, or have yet to fully incorporate the reminiscence bump phenomenon. This paper addresses these gaps by furthering the development of a virtual home that incorporates reminiscence therapy to address the symptoms of dementia. The developed prototype was evaluated through functional and user testing, and validated by domain experts. Results show an 81.25% completeness rate, 80% functionality rate, and ratings of 4.32, 4.29, and 4.25 for the application's functional suitability, usability, and virtual home experience, respectively. There is a need to improve user controls, but overall, the study shows promise for the virtual home as a tool for therapy sessions.

Keywords: dementia, reminiscence therapy, virtual reality, virtual home

1 INTRODUCTION

Dementia is an umbrella term for conditions and symptoms involving cognitive decline that is severe enough to affect a person's day-by-day activities [1]. It impairs an individual's ability to think, remember, and make decisions.

Around 55 million people worldwide are estimated to have dementia [2]. In the Philippines, there is a high dementia prevalence of 10.6% among older adults, which is higher than the estimated prevalence of 7.6% for Southeast Asia [3]. From this rate, dementia cases in the country are projected to be at 1,474,588 by the year 2030 [4].

The behavioral and psychological symptoms of dementia (BPSD) are specific disturbances that affect people with dementia, such as apathy, depression, aggression, anxiety, sleep and motor disturbances, irritability, disinhibition, and hallucinations [5]. The occurrence of BPSD could be associated with distress in patients and caregivers, long-term hospitalization, misuse of medication, and increased healthcare costs [5].

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In general, there is no known cure for dementia. Instead, most focus is put on the treatment and alleviation of symptoms. Pharmacological treatment is done via medicine prescribed by a doctor to target specific symptoms. In the Philippines, treatments for dementia are mostly limited to drug medication and home care [9]. However, patients may be hesitant with using drugs as medication because of cost, too many medications, fear, and mistrust [11].

On the other hand, non-pharmacological treatments are done without medicine. These interventions are considered as strategies to address BPSD, stimulate cognitive function, and improve the quality of life for patients [7]. Treatments of this type include music therapy, art therapy, and physical exercises [6].

One particular non-pharmacological intervention is reminiscence therapy, which uses all senses to help patients remember events, people, and places from the past [7]. This is usually done through a discussion of memories, using tangible objects such as photographs and music [7]. Reminiscence therapy targets the reminiscence bump phenomenon, which suggests that older people most remember the memories from their youth and early adulthood, specifically when they were aged 10-30 years old [8].

Recent research efforts have considered the use of virtual reality (VR) in the conduct of reminiscence therapy sessions. In the Philippines, a VR application for dementia therapy which uses collective memory, or the memory shared by a group of people, as a personalization scheme was designed [9]. It featured a virtual house with elements based on the Filipino 1960's-1980's time period.

Another local study focused on the management of BPSD by having patients visit a virtual environment that features familiar places in the Philippines such as Rizal Park and Palawan [10]. Patients could perform painting, puzzles, and music activities while being guided by a virtual companion. The application was implemented on Oculus Quest 2–maximizing the device's hand tracking and gesture detection capabilities.

While these local non-pharmacological advances exist to supplement dementia therapy through the use of VR software [9,10], they have only been partially implemented and have yet to conduct usability testing [9], or have yet to fully incorporate the reminiscence bump phenomenon [10].

1.1 Objectives

To address the gaps in existing studies, this research aims to develop a virtual home that incorporates reminiscence therapy and the reminiscence bump phenomenon to address BPSD and create real experiences for patients with dementia.

In order to achieve this general objective, the following specific objectives are identified:

1. List design strategies based on the following considerations.
    a. Usability ensures that target users, or elderly dementia patients, can use the application despite having decreased motor and cognitive abilities.
    b. Personalization helps users to adjust inside the virtual home through the use of familiar and recognizable elements.
    c. Portability allows the software to be implemented in other platforms for better accessibility and immersiveness.

2. Develop the virtual home with the following features guided by activities found in traditional reminiscence therapy. The first four features are considered in [9], while the last feature is considered in [10].
    a. **Personal memory elements**
    Personal photos of the user can be uploaded to the application. This will show up in the virtual home through a picture frame and is meant to trigger reminiscence of memories and personalize the user's experience.
    b. **Interactive activities**
    Household routines, such as watering the plants and setting the table, are tasks that patients with dementia may have difficulty doing in real life. These were included in the virtual home as simplified activities that they can perform.
    c. **Relaxing activities**
    To induce relaxation in patients with dementia, activities, such as watching the TV and listening to the radio, were included in the virtual home. TV programs, commercials, and songs from a past time period were used to target the reminiscence bump phenomenon.
    d. **Scenery**
    Two kinds of scenery were included in the virtual home: the home environment itself and nature. These allow patients to visit places that they may have difficulty going to given their condition.
    e. **Caregiver features**
    While the user is inside the virtual environment, the caregiver can control the virtual home through a caregiver view. This allows the caregiver to control the flow of the application and guide the user throughout the experience.
3. Conduct testing to determine the quality of the software developed.
    a. **Functionality Testing**
    An internal test was conducted to provide an objective assessment of the application's completeness, functionality, strengths, and weaknesses.
    b. **Validation from Domain Experts**
    Consultations with neurologists and project developers from [10] about the virtual home and its features were conducted as a way of determining the suitability of the application and its potential use for dementia patients.
    c. **User Testing**
    Testing was conducted with healthy volunteers in order to evaluate the application's usability and software quality, as well as to gather feedback for future improvement. The quality of the application was evaluated using the standards of the ISO/IEC 25010 model.

2 THEORETICAL AND CONCEPTUAL FRAMEWORK

The theoretical and conceptual framework lays out the foundation and flow of the research. It details the relationships between key ideas and processes that lead to the creation of the virtual home. As shown in Figure 1, the framework has the following four main stages:

- **Requirements Analysis**
  The symptoms of dementia, practices in traditional reminiscence therapy, as well as considerations of current research efforts were identified. These constitute the requirements of the application.
- **Software Design**
  Use-cases that define what users and caregivers are able to do in the application were formulated. Design strategies were also identified based on the considerations of usability, personalization, and portability. Both of these are taken into account in determining the application's features.
- **Software Development**
  A prototype of the virtual home was created with features that meet the research objectives.
- **Software Testing**
  The quality of the developed application was evaluated. Gaps in the software design were also identified for the virtual home's future improvement.

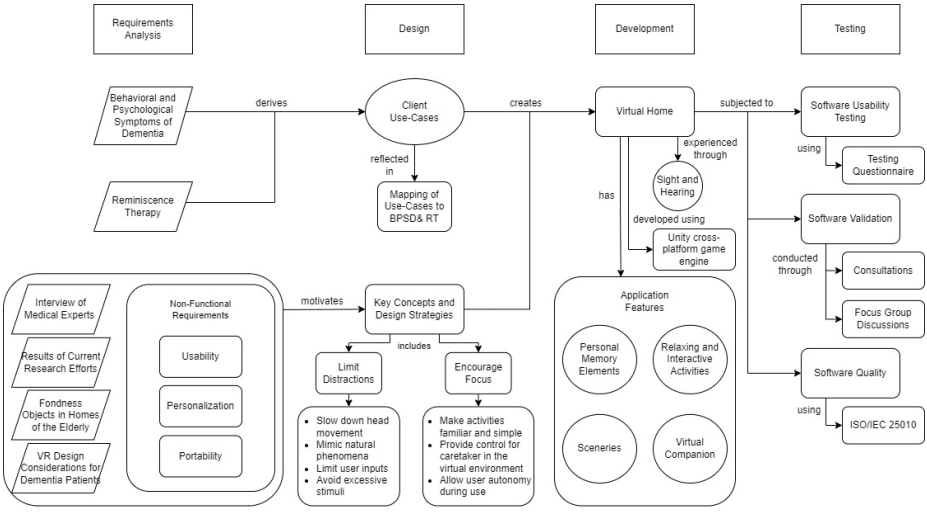

Fig. 1. The theoretical and conceptual framework for the virtual home

3 APPLICATION DESIGN

The VR application is entitled "Home Bound", which means on the way home. From [9], several models for the virtual home elements have already been created, and these were retained in this study. Additional new models were also included, such as tableware items and birds.

An initial proposed design for the software is presented in [22]. In this paper's succeeding sections, the discussion focuses on features that were developed for the application prototype, tests conducted to evaluate the application and their results, as well as recommendations for the application's improvement.

3.1 Design Strategies

As part of the research objectives, the following strategies were identified, so that the application incorporates reminiscence therapy and the reminiscence bump phenomenon, while ensuring that it is usable for elderly people with cognitive impairment. They are meant to encourage focus and limit distractions for dementia patients.

These strategies were derived from findings of previous research efforts and a review of related literature. The researchers also looked into the basics of usability in user interface design [16], which in the present study, is embodied as interactable objects and use-cases in the virtual home.

1. **Familiar and simplified activities**
   In line with the reminiscence bump phenomenon, this strategy focuses on making activities familiar by including the user's personal photos in the virtual home and basing application features on objects and experiences from the past time period [9]. This can help users with reminiscence of their memories and adjustment to the virtual environment. Activities are also simplified to ensure that they are easy to accomplish even with decreased cognitive abilities [10]. In addition, hand gestures were used for environment controls instead of VR controllers for better learnability of the application, similar to [10].
2. **Inclusion of the caregiver**
   As noted in [10], the caregiver is an integral part to the provision of dementia therapy, and should be included in the application, so they can guide the user inside the virtual home. Features to control the virtual home, along with guides such as a built-in timer and statistics about real-time use of the application, can help caregivers in conducting a guided and meaningful therapy session in the virtual home according to what each user needs. A virtual companion in the environment can also help to minimize feelings of isolation in the user [10].
3. **User autonomy**
   As an application that simulates a home, users should feel that they have free will to explore the environment just like in real life [17]. For instance, users can freely choose which area of the home to visit or which activity to perform provided that they are already accustomed to the virtual environment and its controls. Open-ended activities can also contribute to this by allowing users to do

what they want instead of following a set outcome. This strategy is in line with the Montessori approach to treating dementia [20].

4. **Limiting user movement**
   Given that the target population is elderly dementia patients, their safety while using the application is also an important consideration. There is an increased risk of falls for this patient demographic [13], and motion sickness may also occur with the use of VR technology. As such, this strategy minimizes the head and body movement of users by keeping them seated throughout the use of the application, and arranging important features such that they are directly in front of the user and are closer together. This reduces instances of users having to turn their head and/or body to interact with objects in the virtual home.
5. **Mimicking natural phenomena**
   From [10], unrealistic elements may cause confusion in users since there is a disconnect between what they expect to happen in reality and what actually happens in the virtual environment. Along with an unfamiliarity with the technology, this can affect the users' engagement with the application. As such, the displayed behavior of objects in the virtual home should be as close to reality as possible, and controls for interacting with the environment should be intuitive [18].
6. **Visual and aural constraints**
   Too much visual and aural stimuli may overwhelm elderly dementia patients [21]. In line with this, constraints in the virtual home were enforced, such as using slow transitions, arranging objects to avoid clutter, and making sure colors are not bright and the music is not loud.

3.2 User Features

The virtual home has four accessible areas, which are the entrance, living room, dining room, and garden. Each area has objects that the user can interact with using hand gestures. The user can also look around while inside the virtual environment. The original layout in [9] was rearranged to keep accessible areas and interactable objects closer together to decrease the head movement of the user as shown below in Figure 2.

Fig. 2. Top view layout of the virtual home

Fig. 3. Entrance of the virtual home

Since the user remains seated throughout the use of the application, navigation through the virtual environment is done through teleportation. This was implemented with the point and pinch gestures wherein the user points to a location and pinches to teleport. As seen in Figure 3, a white line is also casted whenever the user is pointing to visually guide them.

Upon entry into the virtual environment, the user first sees the entrance to the virtual home as also shown in Figure 3. Interacting with the front door lets the user enter the virtual home. The activities in each area are enumerated as follows:

1. **Living Room**
   a. **Watching the television.** The user can turn the television on or off by picking up a remote. A compilation of old shows and commercials will play when the television is turned on.
   b. **Listening to the radio.** The user can turn the radio on or off by pushing a button. A compilation of old songs will play, and an antenna will appear when the radio is turned on.
   c. **Viewing the picture frame.** Personal photos that are uploaded to the application will show up in the virtual environment through the picture frame.
2. **Dining Room**
   a. **Setting the table.** The user can set the table by grabbing and placing tableware items on the dining table such as a mug, spoon, and fork as seen in Figure 5.
3. **Garden Area**
   a. **Watering the plants.** The user can water plants found in the garden by squeezing a spray bottle as seen in Figure 6. Watered areas of the plant also glisten to indicate moisture.
   b. **Viewing nature.** The user can observe the plants, trees, and birds in the garden by sitting on a rocking chair as seen in Figure 7. This is in line with the concept that nature sights and sounds can help in lessening the stress and anxiety of patients [13].

Fig. 4. Living room of the virtual home

Fig. 5. Dining room of the virtual home

Both the television and radio in the living room are meant to induce relaxation in patients to manage the symptoms of dementia. Both activities of setting the table in the

dining room and watering the plants in the garden area are meant to simulate the experience of doing household chores since dementia patients may have difficulty performing them in real life.

Fig. 6. Watering plants activity

Fig. 7. Viewing nature activity

3.3 Caregiver Features

The caregiver can control the virtual home directly from the Unity Editor. As shown in Figure 8, a caregiver view can be accessed in the editor which the caregiver can use to guide the user. The parts of the caregiver view are enumerated as follows.

1. **User View.** The caregiver can see what the user is seeing while they are inside the virtual home.
2. **Timer.** The caregiver can use the timer as a guide for the duration of the session since there is a recommended time limit of 15-20 minutes.
3. **Companion Controls.** The caregiver can operate a virtual companion in the environment by making the companion perform emotes to engage with the user.
4. **Teleport Control.** The caregiver can turn the teleportation feature on or off as a way to limit the input of the user and to avoid accidental teleportation since the system is sensitive to gestures.
5. **Statistics.** The caregiver can view the amount of time the user has spent in each area of the house. This can help in identifying which activities the patient is more receptive to and which activities can be further improved.

In addition, the caregiver can also upload a personal photo of the user which can further aid reminiscence. This photo will show up in a picture frame in the living room as discussed in the earlier section.

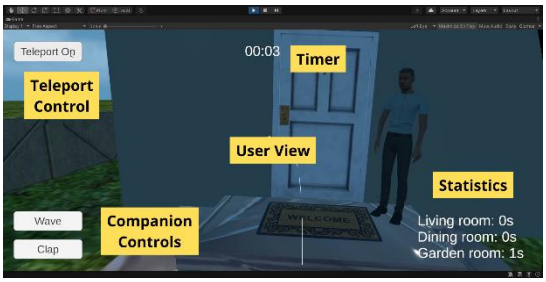

Fig. 8. Caregiver view of the VR application

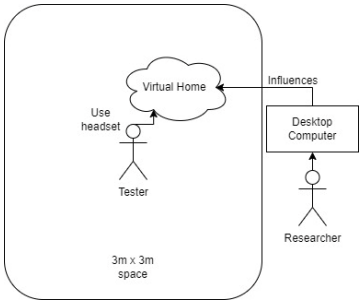

Fig. 9. Diagram of testing setup

3.4 Implementation Details

These features were created during the development phase of the project. For specific implementation details, the application was developed using Unity, a cross-platform game engine as it would make the software portable. The VR headset used is the Oculus Quest 2 which has hand tracking and gesture recognition capabilities. An Oculus Link cable and an Acer Nitro 5 with an AMD Ryzen 7 5800H processor and 16 GB RAM were also used as these are both needed to launch the application smoothly from the Unity Editor and to enable the caregiver features.

4 APPLICATION TESTING

The following tests were conducted to evaluate the quality of the developed prototype as a VR application. These are also meant to identify gaps in the software design and provide recommendations for future improvement.

1. **Functional Testing**
   An internal functional test was conducted to provide an objective assessment of the application's completeness with respect to identified use-cases, functionality with respect to its developed features, and its strengths and weaknesses.
   A list of use-cases and test cases was prepared for the functional test. Each use-case and test case was marked as completely or partially accomplished. The strengths and weaknesses of the prototype were identified based on qualitative observations during the development and testing stage of the project.
2. **Validation from Domain Experts**
   Since the participants of the user testing will not include actual dementia patients, the suitability of the application to manage the symptoms of dementia was evaluated through feedback gathered from domain experts. Consultations were held with neurologists from the University of the Philippines Manila and project developers of [10] throughout the application's development stage.
3. **User Testing**
   A total of 27 healthy and natural-born Filipino volunteers aged 18 to 59 years old and currently residing in Metro Manila were invited to test the application.

Out of the 27 testers, 22 belonged to the 18-39 years old age group, while the remaining 5 belonged to the 40-59 years old age group.

The user testing was conducted at the Service Science and Software Engineering Laboratory in the University of the Philippines Diliman. The volunteers were informed about the purpose of the test, how it will be conducted, and where the feedback they provide will be used.

The participants were also given a testing questionnaire in order to gather their feedback for the application. Questions related to their experience while using the VR headset and while inside the virtual home, as well as the quality of the application, were asked. These questions vary in nature such as yes–no, WH, and 5-point scale questions.

The questionnaire in [10] was used as the primary reference, while the standards of the ISO/IEC 25010 model were used, particularly the characteristics of functional suitability and usability [19], in formulating the questions related to software quality.

The setup of the testing is shown in Figure 9. Throughout the duration of the testing, the tester was seated on a swivel chair. A 3m by 3m space was prepared for testers to freely move around in. The VR headset was fastened to the tester for them to experience the virtual home.

The researchers were seated nearby in order to guide the tester throughout the testing session. The caregiver features of the application were accessed through a laptop that the researchers used to control the virtual home.

5 RESULTS AND DISCUSSION

5.1 Functional Testing

Through a series of internal tests, the functional testing provides a quantitative assessment of the application in terms of its completeness and functionality, as well as a qualitative assessment of its strengths and weaknesses.

Out of 8 identified use-cases, 5 are fully accomplished and 3 are partially accomplished as seen in Table 1. The completeness rate was computed using the formula (5 + (3/2)) / 8 = 0.8125 wherein 5 represents the fully accomplished use-cases, 3 represents the partially accomplished use-cases which is halved to represent partial completion, and 8 represents the total number of use-cases. This corresponds to an 81.25% completeness rate.

Use-case	Result
User	
Reminisce memories	Fully Accomplished
View sceneries	Partially Accomplished
Accomplish household activities	Fully Accomplished
Relax in the virtual home	Fully Accomplished
Caregiver	
Start/End the application	Fully Accomplished

Operate virtual companion	Fully Accomplished
Upload personal photos of user	Partially Accomplished
View statistics	Partially Accomplished

Table 1. The application's use-cases

Meanwhile, out of 55 identified test cases, 44 are fully accomplished. The remaining 11 test cases correspond to issues in the responsiveness of user controls and the behavior of interactable objects inside the virtual home. This corresponds to an 80\% functionality rate.

For the qualitative assessment, the researchers summarized the observed strengths and weaknesses of the developed prototype through Table 2 below.

Strengths	Weaknesses
• Each use-case was included in the application. • Features were developed for each accessible area of the house • Users have the capability to interact with items in the house using hand gestures • Important design considerations, as identified in [10] were included, such as the virtual companion and use of hand gestures	• The teleportation system is prone to cause bugs • Hand gestures are sometimes difficult to detect by the VR headset • Some originally planned features were not implemented, such as a photo album and inclusion of real locations for viewing

Table 2. The application's strengths and weaknesses

5.2 Validation from Domain Experts

From initial consultations with neurologists during the project's design stage, no major concerns have been identified for the software design. They also noted that the application contains unique features different from [10], which suggests novelty as a VR application for dementia. However, no feedback from the neurologists for the current prototype has been gathered yet.

On the other hand, the project developers of [10] recognized that the application clearly incorporates reminiscence therapy. This is particularly evident in the following activities: watching TV, listening to the radio, and watering the plants. However, they suggested that interactable objects in the virtual home should be highlighted.

5.3 User Testing

The results of the user testing can be discussed according to three categories: functional suitability, usability, and virtual home experience. Each category has a corresponding score obtained by calculating the mean of means value of relevant 5-point scale questions in the questionnaire. This is summarized in Table 3 below.

Category	Score
Functional Suitability	4.32
Usability	4.29
Virtual Home Experience	4.25

Table 3. Summary of scores obtained from user testing

Functional suitability measures how functionally correct and appropriate the application is for elderly dementia patients. The volunteers noted that the graphics and music used were appropriate and accurate. The arrangement of objects inside the virtual home were not cluttered, and movements such as transitions and animations were slow, which are both necessary to avoid overwhelming patients. Interactions with the virtual environment through hand gestures were mostly natural except for the teleportation. The virtual companion enhances the virtual home experience, but the rationale for its presence is not apparent.

Usability refers to the ease of use of the application. The questionnaire responses show that it was easy to learn how to use the application, the activities in the virtual home were easy to perform, and the music and sound effects were audible. The volunteers felt that guidance was necessary in order to use the application. The application was fairly responsive to hand gestures, but the teleportation, in particular, was difficult to perform. The graphics were mostly clear, but can sometimes be shaky.

Virtual home experience looks into the perception that users have towards the virtual home. The application generally induced feelings of relaxation in the volunteers, particularly through the garden area and the music used. It was also noted that the graphics were mostly realistic. However, the volunteers felt that the application can overwhelm users that have no prior VR experience, and that it can seem limiting due to the few number of activities available.

In addition, several insights were also obtained from the questionnaire responses. For instance, watering the plants and watching TV were the most liked and least liked activities, respectively. The volunteers also spent the most amount of time in the garden area. The design details included in the virtual home such as the trees, birds, and ceiling fans contributed to the virtual home experience. There was positive feedback on the interactiveness of the application, but some volunteers felt that they were either too tall or floating.

However, it is also important to note that the virtual home can be notably different from the dementia patients' actual home, which can hinder them from fully adjusting in the virtual environment. To address this, efforts to make the virtual home more familiar and recognizable can be included such as adding more personal memory elements, enabling customized furniture, making the home objects as accurately modeled as possible, and creating a variety of activities to cater to patients' varied interests.

6 CONCLUSION

The present study accomplished its research objective of developing a virtual home that incorporates reminiscence therapy and the reminiscence bump phenomenon to address the symptoms of dementia. In particular, design strategies from findings of existing research efforts and related literature were identified to aid in creating a usable application for elderly dementia patients, the features of the application were developed based on activities in traditional reminiscence therapy, and testing was conducted to evaluate the application's quality.

Since the present study is also a continuation of [9], it was able to contribute to the previous research an updated list of design strategies which included findings from [10]. The previous application's features were further developed by adding interactive elements, using hand gestures for controls, and including the caregiver in the virtual environment. Feedback for the virtual home's improvement was also received as a result of the conducted testing.

Overall, the prototype serves as a proof of concept for a virtual home that incorporates reminiscence therapy. However, major design issues have yet to be identified, and there is a need to improve user controls as shown by the results of the conducted testing. Given that this research only evaluated the virtual home as a usable software application, future work can involve testing with actual dementia patients in order to fully evaluate the application's effect to manage the symptoms of dementia. Nevertheless, the results suggest feasibility for further development and future implementation of the virtual home as a tool for therapy sessions. If the software were to be fully developed, it can be used as a stand-alone application, or it can be integrated into a bigger project such as [10].

7 RECOMMENDATIONS

The existing features of the current prototype can be modified to improve the usability and user experience of the application. For instance, refining the teleportation feature to simplify controls is highly recommended as volunteer testers found it difficult to perform. A point and wait system may be implemented instead of the point and pinch. The virtual companion can also be placed in a more active role, such as including it in doing household activities.

The ability to switch channels for both the television and radio can be added as most testers expected this behavior in the application. The architecture and overall design of the house may also be enhanced to better fit the Filipino 1960's-1980's time period and provide a more familiar virtual home experience.

In addition, features that were not implemented may be added in future versions of the prototype to improve the usability and reminiscence component of the application. Interactable objects should be highlighted to make interactions in the virtual home clearer and more intuitive for the users. Adding a photo album which users can browse and arrange, as well as a feature to view real locations through a 360° picture or video, can further help in managing the symptoms of dementia.

The addition of a tutorial section at the beginning of the application can help users, particularly those who are unfamiliar with the technology, to better adjust to the virtual environment and learn the user controls. Optimization of project files, such as lowering the textures of faraway objects and disabling unnecessary parts of the code, may help to address concerns of lag in the application and improve performance.

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