

GunitaHu: A VR Serious Game with Montessori Approach for Dementia Patients During COVID-19

Aira Jazel Y. ANG^a, Roberto D. PRINCIPIO Jr.^a, Richelle Ann B. JUAYONG^a and Jaime D.L. CARO^a

^aService Science and Software Engineering Laboratory, Department of Computer Science, University of the Philippines Diliman

Abstract.

The study aims to explore VR Serious Games as a form of therapy for people with dementia. It seeks to establish the utility of VR-based interventions with the application of Montessori Method. This study also serves as a basis for researchers, healthcare professionals, and developers who plan to incorporate VR therapy with other therapeutic approaches and to create a system that may be replicated for other illnesses via telemedicine to address the most vulnerable sectors. The main beneficiaries of this study are people with dementia and those who directly interact with them such as their doctors, caregivers, and family members of the patient.

Keywords. dementia, virtual reality, telemedicine, montessori method

1. Introduction

According to the World Health Organization [1], dementia is a syndrome in which there is deterioration in memory, thinking, behaviour and the ability to perform everyday activities. There are currently around 50 million people affected with dementia and almost 10 million new cases each year. With a projection of 82 million by 2030 and 152 million by 2050, researchers are continuously trying to find a cure for dementia.

There are pharmacological and non-pharmacological treatments for dementia. For pharmacological treatments, the commonly prescribed medicine to the patients are mostly to regulate the hormones related to learning, but they have short effectiveness and may cause side effects in the long run, example of these are cholinesterase inhibitors and memantine [2]. Non-pharmacological treatments include multiple types of therapies that are used to alleviate the symptoms of dementia. One study explores reminiscence therapy on dementia [3]. It involves discussion of memories and past experiences using photographs and music as mementos for memories. The study claims that the therapy has some positive effects on quality of life, cognition, communication, and mood. Game therapy is another kind of therapy that improves cognitive functions [4] along with social and emotional functions [5].

Virtual Reality is a promising technology for therapy for its real-life scenario simulation without risk. Interventions using VR can be useful for people with mild cogni-

tive impairment or dementia [6]. Content, immersion, and controls must be taken into account for persons with dementia [7]. In this study, VR technology is implemented as a serious game. This meta-analysis on VR-based interventions states that VR is cost-effective, flexible, comprehensive, and potentially useful for patient-centered care. VR therapy has a positive effect on physical fitness, cognition, and emotion. Dementia patients would benefit greater accessibility in their own homes or residential aged care since each experience can be tailored to the interest of the patient [7].

Due to the nature of COVID-19, older adults with dementia are more vulnerable in contracting COVID-19. Hence, local authorities have banned visits to nursing homes and long-term care facilities [8]. Anxiety and depression are the most common psychological effects caused by the pandemic. It also raises the issue of high rates of pre-existing depressive symptoms in the elderly and lack of access to mental health care [9]. Technology-based interventions that can be remotely accessed by people with dementia can address this problem [10]. Due to COVID-19, progress of telemedicine has hastened [11]. This study is a response to the need for more technology-based interventions for people with dementia.

The Montessori Method dates back to the 1900s when Dr. Maria Montessori was looking for a scientific approach to teach children. The philosophy revolves around bringing the person's potential by giving him creative freedom in an environment. Later on, researchers and doctors start to apply the concept to dementia patients where he reminisces his interests or hobby then work the therapy from there [12]. According to [13]van Rijn's team, the Montessori principles applied should include the following: (1) cueing, (2) building on existing skills, (3) providing clear specific tasks related to an activity, and (4) multisensory activities. The Montessori method is a very helpful way to help the patient set up the environment he is most comfortable with as the main goal is to make the patient feel more independent and at the same time boost his sense of purpose, so he will not feel like a dead weight [14]. For this study, we are going to focus on individual engagement rather than group activity due to the pandemic.

2. Objectives and Considerations

The study has four primary objectives: (1) Develop A VR Serious Game with Montessori Approach, (2) Add a real-time system for the application, (3) preserve VR application features for dementia and (4) test for usability, and user feedback with performance metrics and analysis of the application.

The first objective consists of two features: (1) Contain a variety of Montessori-based activities, with a touch of (2) personalization [15]. The rooms are divided into two where each room has its own set of Montessori activities

1. Living Room - Activities are (1) Turning on the TV and (2) the radio. Personalized features are (1) Television show, (2) Radio music, (3) Book, movie, poster covers and (4) Personal photographs.
2. Lanay or Garden - Activities are (1) Flower arrangement and (2) watering plants.

The second objective is to develop a real-time system for the VR application. The patient and caregiver can be in the same virtual room in real-time. This objective addresses the specific constraints and additional conditions brought about by COVID-19.

The third objective consists of the following features: (1) have easy-to-understand game mechanics, (2) have intuitive interface and controls, and (3) provide an ambient environment. The study uses the Serious Game design assessment framework [16] to further expand upon these features.

The fourth objective is to do various tests on the application. Namely, these are System Usability Test, user feedback, and performance metrics and analysis on the application.

3. Application Design

The conceptual framework used for this study is divided into 4 parts corresponding to each of the main objectives. The first part is about developing the game with Montessori approach. To ensure that the game follows the Montessori approach, the activities are designed following the Montessori Principles that [13] used in designing their own game. Rather than introducing new skills, it is important to build on the existing skills of the patients to prevent frustration. Clear and specific tasks must be provided to make sure that the patients understand such as visible cues. Finally, activities must be multi-sensory and dynamic. Adhering to these principles support the Montessori approach of the application.

The second part is supported by [17], stating that there is indeed an existing need for a remote connection between patients and caregivers. COVID-19's restriction on social distancing can be alleviated through the use of telemedicine, therefore a real-time system for the application is a crucial component.

The third part uses the Serious Game design assessment framework (SGDA) provided by [16] to preserve VR application features. There are 6 key design elements: (1) purpose, (2) content & information, (3) game mechanics, (4) fiction & narrative, (5) aesthetics & graphics and (6) framing.

- Purpose - The main purpose of the application is to develop a VR serious game with the Montessori approach, provide a comfortable, relaxing, and entertaining experience, accommodate various hobbies and interests by providing a multitude of Montessori-based activities, and improve overall quality of life of the patient
- Content & Information - The Montessori-based activities that were chosen to be included in the application are from literature and professional opinion. Simple and straightforward instructions are given to the user for each activity.
- Game Mechanics - The application offers different types of activities. To keep the game simple and easy to use, the application only features one game mechanic: point-and-click.
- Fiction & Narrative - The application is a collection of different Montessori-based activities. The user does not need to keep track of a linear story as there is none. This ensures that the user focuses on the gameplay itself.
- Aesthetics & Graphics - The application's interface is intuitive in order to prevent overwhelming the user with information and cause confusion. The application has simple yet recognizable graphics. There is an ambient environment with background music for relaxation. Auditory and visual cues are present to aid the patient.

- Framing - The target audience for the application is people with dementia. The game design is specifically developed for their usage, from the game mechanics to the user interface. The caregiver personalizes the virtual world for the patient.

The final part is testing the application using the Software Usability Scale [18] and performing user interviews. Performance metrics and analysis are also done.

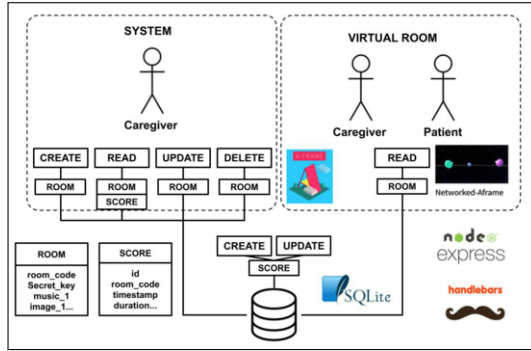


Figure 1. Application Architecture

The application is a web application using NodeJS and Express and Handlebars as its view engine. The database used is SQLite as it is good for small-scale prototypes. There are two tables in the database. The first table is the room table that contains information about a specific room such as patient name. The second table is the points table that contains post-session data for the caregiver to analyze later on.

The application is separated into two parts: The system and the virtual room. In the system, the caregiver can perform CRUD (Create, Read, Update, Delete) on the room table, where uploading of personal media is performed. The caregiver may also view the post-session data of the patient.



Figure 2. GunitaHu's Virtual Room

The next part is the Virtual Room which is developed using A-Frame, a WebVR framework and Networked-Aframe built on top of A-Frame used for the multiplayer aspect. The caregiver and patient are able to interact with each other through voice chat, and may interact with the virtual room. After the session, the system automatically cre-

ates a post-session data report of the patient for the caregiver to view later. The pointing system is simple: completing a task gives you a point.

In order to give a nostalgic feeling to the patient, the environment is comprised of a simple home with a living room and a garden.

4. Setup and Implementation Specifics

- Participants - healthy people, preferably those between 50 and 70 years old.
- Equipment - The recommended internet speed is be at least 8mpbs for the videos to load properly with maximum latency of 40ms. The computer on the caretaker side should have an operating system of Windows 10 with a minimum of i3-6100, GPU of NVIDIA GTX 1050 Ti or greater, and 8GB RAM. The Oculus Go is standalone, so there is no need to connect the device to the computer. It has a Qualcomm Snapdragon 835 with GPU of Qualcomm Adreno 540 GPU and 3GB of memory.

The user flow of the patient-caregiver are as follows: Caregiver A is in location A. Caregiver B and Patient are in location B. Caregiver A, using a PC or a HMD connects to the application and enters the virtual room. On the other hand, caregiver B assists Patient such as setting up the HMD, chair, etc. The patient connects to the application thru a HMD. While the session is ongoing, caregiver B monitors the state of Patient and may also view their screen through a PC through screen casting. After the session, the patient exits the virtual world and the caregiver exits and views the post-session data.

5. Testing Plan

The end users of the application are people with mild to moderate dementia. Due to COVID-19, actual testers are healthy participants in the age range of 50 - 70. Clinical testing is outside the scope of this study due to time constraint and the pandemic. As such, the effectiveness of the application is based on usability tests, interviews, not clinical assessments.

The researcher conducts the experiment after setup and profiling the patient then records the patient doing the tasks in any order. The application would give a point for every task done. The session lasts for 30 - 40 minutes with a 5 minute break from the VR experience in between. At the end of the session, the patient answers a questionnaire about usability and user feedback (System Usability Scale)[18]. The source code is publicly available on [Github](#), and the live demo is deployed on [Heroku](#).

6. Conclusion

Exploring this area of Montessori Method integrated in VR is promising. An additional data point such as duration of the session may be helpful for caregivers. This study serves as a case study for future researchers, healthcare professionals, and developers. The COVID-19 pandemic and its effects may persist for a few more years, hence expanding telemedicine is encouraged.

Testing on a larger test sample, as well as on actual dementia patients would be preferable. More scenarios, rooms, and activities would greatly increase the application's features. Enriching some tasks by adding multiple states, such as adding channels on the TV, would also be good. Other game mechanics such as dragging and dropping can be explored by using other VR HMDs with better performance than the Oculus Go. Using a full-fledged game engine like Unity, Unreal, or Oculus SDK allows for more control in the performance side. Healthcare professionals and caregivers can add clinical testing and since the application is open-source, the system may be replicated for other illnesses and ultimately contribute in expanding telemedicine.

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