

AN IMMERSIVE DISEASE TREATMENT AND COGNITIVE RECOVERY SYSTEM FOR ALZHEIMER'S PATIENTS USING ARTIFICIAL INTELLIGENCE AND VIRTUAL REALITY

Xilei Zhong¹, Samuel Silverberg²

¹Conestoga High school, 200 Irish Rd, Berwyn, PA 19312

²Computer Science Department, California State Polytechnic University, Pomona, CA 91768

ABSTRACT

The problem I'm trying to solve is the trouble with Alzheimer's patients in recalling memories. This program will be used as a memory aid to help users with remembering past events through past memory image display. The key technologies I used are Unity, ChatGPT, and DALLE. The application is shown in Unity in Virtual Reality, it sends the memory prompts the user typed in Unity to ChatGPT, then DALLE will generate a memory image that is then displayed in Unity [1].

The three important systems are the ChatGPT prompt, the DALLE generator, and the Unity client. The ChatGPT prompt uses prompt engineering concepts to generate a visual description of what to make, which is then fed into DALLE, which attempts to create an artistic interpretation of the user's memory [2]. This is in turn fed back to the Unity client on the VR headset for display in an art gallery.

Several design considerations and challenges were encountered and resolved along the way. The principal challenge was considerations for user experience. In the end we found that since this is a service used by caretakers and patients alike it was essential to make the program as simple to use as possible, which required some simplification of the UI and strengthening of the backend systems [3]. The experiment results indicate that this design decision was positive.

KEYWORDS

Memory recall, Virtual reality memory aid, ChatGPT, User experience

1. INTRODUCTION

When we age, we are more likely to have Alzheimer's disease [4]. This problem mainly affects elders, but there is also a minority middle-aged population that can have it too. Alzheimer's disease can cause great memory loss and other cognitive difficulties such as getting lost and being unable to complete daily tasks. This problem is important for us to solve because of how severely it affects patients' daily functions. The application is created in hope to prevent Alzheimer's disease from happening and recover memories for the current patients.

Each methodology studied was related to Alzhiemers disease and how that affliction's effects could be mitigated [5]. The first methodology accomplishes this using musical therapy. The paper shows that it does help, but there are a few limitations. One limitation is the fact that some users will not be musically inclined, or may even be deaf. Our app does not require any musical affinity or the ability to hear [6].

The second methodology addresses the challenges of dementia using theater performances. Following the shows, audiences are encouraged to engage with the performance through discussion activities. These live discussions can be great for a variety of audiences due to the human component of discussing. The main shortcoming would be the lack of focus on audiences that are suffering from dementia, as these plays are suited more for a general audience to understand the effects of Alzheimer's disease.

The final methodolgy addressed uses a memory prosthetic to aid users with their memory when conversing with familiar people. This prosthetic can improve the quality of conversation. The main limitation of this would be some users may not be able to properly utilize the prosthetic due to other potential medical issues, whether physical or mental.

I decided to do this program because my mom has told me about her job as a caregiver for patients with Alzheimer's disease. She talks about witnessing them wander, agitate, and behave unusually. It is heartbreaking to hear that they have grown and lived with much intelligence, yet their behaviors and thoughts are not matched. They instead may feel helpless. The issues within seniors community are also largely ignored when compared to how people nowadays are concerned with the new generations. The older generations are more ignored.

The idea of the application "Store memories for Alzheimer's" is for people who want to prevent Alzhiemer's. For example: people whose family generations have had Alzhiemer's, or people who want to be cautious about health issues, or simply just a memory storage place for people who do not want to forget past memories. This program is also for patients with Alzheimer's to assist with keeping track of memories in a visually appealing mode. Especially when the patients of Alzhiemer's have trouble using writings to express their memories/ideas - they can use this as a visual aid to help remember.

The application is unique compared to other solutions because the program is concise and simple to use. We only have two buttons to take you to either create a memory or view previously created memories, with an addition of an exit button on each page. It is also unique due to the incorporated idea of displaying it through virtual reality instead of normal applications on their phone. Users can have a more vivid view and they can potentially recall their memories better.

The experiment ran for this project involved a qualitative assessment on the image generation capabilities of the project's backend, to acceptable results that indicate a strong start for a prototype. Users were able to generate various images of acceptable quality with memory descriptions of various qualities. We had a participant generate 10 images of their own and had them provide two metrics: a painting score, and a relevance score. The averages of both scores were 7.4 and 7.2 respectively, indicating a proficient performance by the backend to generate a quality painting suitable for caretakers and their patients.

2. CHALLENGES

In order to build the project, a few challenges have been identified as follows.

2.1. Save Generated Images

One consideration that went into the design of this prototype was whether or not caretakers should be able to save generated images into a database through an account. We decided to forgo this feature; although it may prove useful for certain groups we believed that the convenience and ease of use of this software is a bigger priority and that users should not need an account in order to utilize the full featureset. Since each time the user runs the program, it is a unique application instance, we felt that account management would be better suited for a secondary prototype.

2.2. User Experience

Another design consideration would be the user experience when generating a painting. Because we want this application to be a relaxing experience for both parties involved, we wanted the user interface to be simple and the process of generating a painting to be easy. For these reasons, the only steps to make a painting are to walk up to a painting in game and enter a description. We intentionally do not ask users to describe the memory in any specific detail for their ease of use and rely on our backend to fill in the blanks.

2.3. Storing Images

Another design challenge had to do with storing images, and whether we should be able to save images to a user's database or local device. We decided that since we did not want user accounts to be involved in the user experience, then we should not save images either. Instead, images are already saved onto OpenAI's servers.

3. SOLUTION

This is an application meant to be used with a VR headset for full immersion [7]. It will take place inside of a simulated art gallery with blank canvases. A caretaker will begin by walking around and interacting with the canvases. For each painting, the caretaker can input a description of a memory that the dementia patient had, and a painting representing that memory will be generated and displayed. To do this, the Unity client will then communicate the typed in memory to a server that interfaces with the ChatGPT API [8]. We use ChatGPT to alter and improve the memory description in case the caretaker's description is vague or too short to gain meaningful info from. We prompt ChatGPT to generate a description of an image to make, and feed that description into another OpenAI service, DALLE, to generate a painting that is representative of the memory that the caretaker typed in. After the caretaker has generated enough paintings, the patient should then be handed the headset and can walk around and interact with the generated paintings in the art gallery setting.

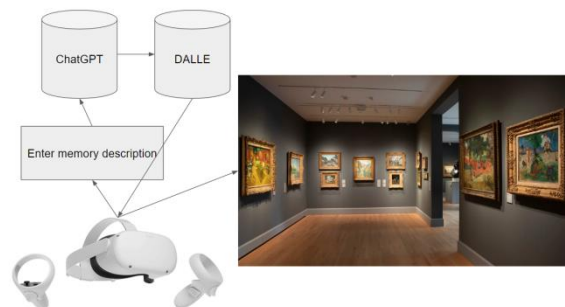


Figure 1. Overview of the solution

One major component of the game is how ChatGPT is integrated. When caretakers input a patient's memory into the game, one concern is that the memory is too vague to make a meaningful painting out of. For example, "halloween" is too vague and a painting generated cannot capture every detail that the patient or caretaker would actually be able to notice. We thus use ChatGPT in order to bolster the imagery of each memory.

```
def generate_image(prompt):
    system_prompt = """You are a helpful assistant.
    A user will describe a memory of theirs to you.
    Generate a more descriptive version of their memory
    that includes more visual descriptors, while remaining
    faithful to the original description.
    """
    response = client.chat.completions.create(
        model="gpt-3.5-turbo-0125",
        messages=[
            {"role": "system", "content": system_prompt},
            {"role": "user", "content": prompt}
        ]
    )
    image_prompt = response.choices[0].message.content
```

Figure 2. Screenshot of code 1

This code is used by the Python server that we connect to this Unity game, which runs off of the Flask microframework [9]. Here, whenever a user inputs a prompt, which represents the raw description given by the caretaker, we use the ChatGPT API used in the openai Python library. We utilize prompt engineering in order to tell ChatGPT what to specifically do with the message. Prompt engineering is the practice of giving specialized templated instructions to a large language model such as ChatGPT in order to acquire specialized and desired responses [10]. Here, we create a custom system prompt to inform ChatGPT that its responses must be visually descriptive and that the provided raw memory description may lack information that could be captured through a visual medium. We utilize ChatGPT 3.5 turbo but this system works with any subsequent model of ChatGPT, including ChatGPT models 4, 4o and 4o mini.

The second component used, right after the ChatGPT component, is to utilize a generative AI image generator model such as OpenAI's DALLE, to create a painting based off of the user's description of a memory. It is essential that the image generated is a quality image that can evoke emotions within the patient.

```
print("Generating...")
response = client.images.generate(
    model="dall-e-3",
    prompt=image_prompt,
    size="1024x1024",
    quality="standard",
    n=1,
)
image_url = response.data[0].url
print("Complete!...")
print(image_url)
return image_url
```

Figure 3. Screenshot of code 2

This code comes right after the code used in the previous component. After ChatGPT is able to generate a more descriptive image prompt than the raw description given, the output is fed directly into another OpenAI service, DALLE. DALLE works like ChatGPT but its output format is in images, not text. We chose to go with DALLE as it generated the best images out of all competitors and we had the most control over it. We utilized a 1024 by 1024 image, the recommended size to go with, and set the quality to standard as higher quality images did not have a discernible difference. When DALLE finishes generating an image, it is saved in

OpenAI's server database and is easily accessible through a blob URL outputted by the API. We send this URL back to the Unity client to display.

The memory gallery is a way for each user to view previously generated memories. The memories are stored remotely for the user in a database. The user can name the memories and create different categories to put them in. The categories are displayed as files on the screen. The user can delete the memories if desired, which can be restored within 30 days.

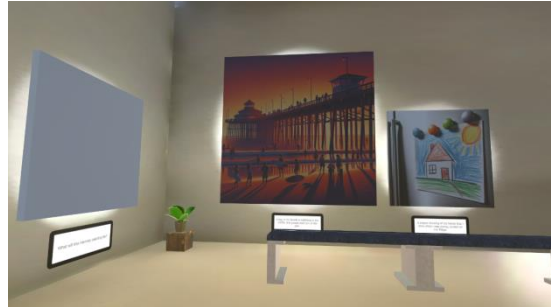


Figure 4. Screenshot of the images

```
0 references
public void RequestImage(string prompt)
{
    string uri = APILink + "/get_image/" + prompt;
    StartCoroutine(GetAPIRequest(uri));
}

1 reference
IEnumerator GetAPIRequest(string uri)
{
    using UnityWebRequest webRequest = UnityWebRequest.Get(uri);
    // Request and wait for the desired page.
    yield return webRequest.SendWebRequest();

    switch (webRequest.result)
    {
        case UnityWebRequest.Result.ConnectionError:
        case UnityWebRequest.Result.DataProcessingError:
            break;
        case UnityWebRequest.Result.ProtocolError:
            break;
        case UnityWebRequest.Result.Success:
            string imageUrl = webRequest.downloadHandler.text;
            imageUrl = imageUrl.Substring(1, imageUrl.Length - 3);
            Debug.Log(imageUrl);
            DLImage.setImage(imageUrl);
            break;
    }
}
```

Figure 5. Screenshot of code 3

This code is used in the Unity client and interfaces with the Python Flask server which houses the previous two components. This code is run whenever the caretaker submits a description into a designated form field. We call the server inside of the coroutine `GetAPIRequest`, which will send an HTTP request to the server and await further execution until the server sends back a response. We sent specifically a GET request to the server base URL at the endpoint “`get_image`”. Afterwards, we can determine the result of the response. If the response was successful, then we need to parse out the URL of the image link sent by the server, which requires some substring manipulation. Afterwards, we reference another component called “`DLImage`” to display the image as a painting in game. The “`DLImage`” component is attached to each painting game object, and when called it will replace the material it's attached to with a new one with an image as a texture.

4. EXPERIMENT

The effectiveness of this program is entirely contingent on whether users believe that the generated images are representative of the memories that they typed in. As such, it is incredibly important for us to determine if our algorithm and system for generating such images needs further improvement. We perform a qualitative experiment to see how users respond.

In this experiment, various memory descriptions were fed into the game system to see what would be generated. The logs from the server of the ChatGPT-modified description of the memory and the raw memory description were recorded. A participant who gave the initial description was then shown the generated painting and asked to rate the design of the artwork as well as the relevance of the artwork to their initial description from a qualitative rating of 1 to 10. The subject was encouraged to give various descriptions, including those which could be reasonably classified as too vague or overly descriptive, in order to gauge the system's effectiveness at adding meaning and possibly removing meaning from an inputted prompt.

Raw	ChatGPT Processed	Painting Rating	Relevance Score	Any Notes
The zoo	Create a vibrant scene of a lively zoo filled with various animals, such as elephants, lions, and monkeys. Include visitors marveling at the animals, with children pointing in excitement. The background should feature lush greenery and colorful structures of animal enclosures.	7	6	"A bit generic"
I remember going to the zoo as a kid with my mom before she passed away. I remember the lion exhibit.	Paint a poignant scene of a young child standing in front of a lion exhibit, gazing in awe at the majestic lions lounging in the sun. The child should be holding a colorful balloon, and their mother should be kneeling beside them, smiling gently as they share this special moment. Surround the exhibit with lush foliage and a warm, golden light to evoke a sense of nostalgia and love.	8	10	
drew a crayon	Create a cheerful crayon	9	9	"Actually not that far off"
drawing of my house and my dad's car	drawing of a cozy house with a welcoming front yard, complete with flowers and a picket fence. In the driveway, illustrate a bright, colorful car that represents the child's dad's vehicle. Surround the scene with a blue sky, fluffy clouds, and a sunny atmosphere to capture the innocence and warmth of childhood memories.			from what I remember"
Santa Monica beach in 1968	Illustrate a nostalgic scene of Santa Monica Beach in 1968, featuring families enjoying the sun, children playing in the sand, and colorful umbrellas dotting the shoreline. Include a classic wooden pier in the background with vintage amusement rides and surfers catching waves. Capture the vibrant atmosphere with a warm sunset casting golden hues over the beach and lively beachgoers in 1960s fashion.	6	7	"Doesn't really feel like 1968. But the beach is fine"
I lived in southern china when I was a kid	Create a serene landscape of a traditional Southern China village, showcasing lush green rice paddies and misty mountains in the background. Include charming, wooden houses with tiled roofs and a narrow winding path leading to a small temple. Add children playing nearby and an	6	4	"Too rural. I lived in the city."

	elderly person tending to a garden, reflecting the peaceful and communal atmosphere of childhood in that region.			
china	Create a captivating landscape of China, showcasing a blend of iconic features such as the Great Wall snaking over lush mountains, traditional pagodas nestled in serene gardens, and bustling markets filled with vibrant colors. Include elements like bamboo forests and rice terraces to emphasize the country's rich natural beauty. In the foreground, add people engaged in daily activities, highlighting the cultural diversity and liveliness of life in China.	5	8	"Feels more like a poster"
The summers in Southern China used to be so hot, but the forest outside my house was so pretty too	Depict a vibrant summer scene in Southern China, highlighting a dense, lush forest filled with tall trees and colorful flowers. Include a small, sun-drenched clearing where a child plays, surrounded by the beauty of nature, perhaps with butterflies fluttering around. In the background, show a glimpse of the house, emphasizing the contrast between the hot summer air and the refreshing greenery of the forest.	8	9	"Well done"
I remember winning a writing competition in grade school	Illustrate a joyful classroom scene where a young student stands proudly at the front, holding a certificate for winning a writing competition. Surround them with classmates cheering and clapping, with colorful artwork and books displayed on the walls. Capture the teacher's proud smile in the background, emphasizing the sense of achievement and excitement in that special moment.	8	5	
I won a writing competition in grade school. I wrote a fairy tale about a princess and a knight and it was very well received by my teachers	Create a whimsical scene depicting a young author presenting their fairy tale about a princess and a knight in front of a captivated classroom. Illustrate the princess and knight characters in a storybook style, standing heroically together, with sparkles and magical elements surrounding them. Include the proud expressions of the teachers and classmates, showcasing the delight and admiration for the enchanting story.	10	9	
My first car was a Toyota Prius	Illustrate a bright and cheerful scene featuring a brand-new Toyota Prius parked in a driveway, surrounded by blooming flowers and greenery.	7	5	"Doesn't really look like a prius"
	Capture the excitement of a young driver happily leaning against the car, perhaps with a set of keys in hand and a big smile on their face. In the background, show a sunny day with a clear blue sky, reflecting the joy of owning their first car.			

Figure 6. Table of experiment 1

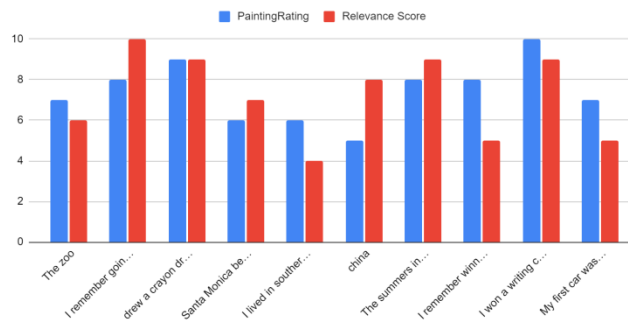


Figure 7. Figure of experiment 1

In terms of the painting rating, which represents what the participant generally thought of how each painting looked, the average score was a 7.4. In terms of the relevance score, which represents how well the participant thought their initial description was translated into a visual medium, the average score was a 7.2. These scores overall suggest that the generator is at least proficient enough to generate most requests, nondescript and overly descriptive, at a somewhat consistent level of quality. The worst performing painting was when the participant said that they lived in southern China growing up. The participant gave it a painting score of 6 and a relevance score of 5. This actually goes against initial hypotheses that predicted that the worst performing score would go to raw descriptions that were the shortest. However, generative AI systems were able to fill in the blanks when necessary; the description “the zoo” earned a 7 and 6 score, respectively.

5. RELATED WORK

This first paper is called “The Use of Music to Aid Memory of Alzheimer's Patients” [11]. The authors are Carol A. Prickett and Randall S. Moore. For this study, ten patients with a probable Alzhiemers diagnosis were selected to participate in multiple sessions that tested how well they remembered words that were spoken versus sung. The result of the experiement reveal that the patients recall words to songs drastically better than spoken words, they are able to participate actively with the use of long-familiar sounds and even capable of learning new songs through humming or keep time. What this program did that ours did not was the experimental nature of it, and it’s through the use of sound to test out whether the patients are able to apprehend and react to music/spoken words. What our program did was to enable the users to put past memories in a form of picture to recall it/remember it. Our system is better because it’s not only an experiment but also the actual content for the users to utilize to memorize.

The source is called “The Remember Project” by an organization [12]. The Remember Project is a community of theatre artists dedicated to fostering dementia-capable communities through the arts by delivering live and virtual performances that address the challenges of dementia. After each show, audience members engage in discussions about the themes of memory loss, with the goal of reaching every county in Minnesota and Wisconsin by 2025, while exploring expansion into other states. What this program did that our did not was the live performance displaying the challenges patients with dementia faced to let people realize the difficulties they faced with daily life. What our program did was to solve the difficulties people with Alzheimer’s or dementia faced through generating pictures related to their memory. Our program is better in solving the problems while the others are representing the problems for a more dementia-inclusive community.

The source is called “Enhancing conversation skills in patients with Alzheimer’s Disease using a prosthetic memory aid” by Michelle S. Bourgeois [13]. The article talks about the effectiveness of training Alzheimer’s disease patients to use prosthetic memory aid when talking with familiar partners, the result is that the quality of the conversational content significantly increased with less ambiguous utterance and the patients are even able to generate untrained statements. Their posttreatment conversation is also improved on all aspects of conversation. The limitation is this tool does not help remember past events but only help with the current activity performance that require intact memories. Our program is better in presenting visual pasts pictures to improve memory and the ability to revisits the memories afterwards repeatedly in memory gallery.

6. CONCLUSIONS

The limitations of my project is that it may not be displayed as 3D images due to the limitation of the things AI will be able to generate [14]. I would like to work on finding resources of AI image generators that will make it more 3D. I want to expand my program in my future through creating sound effects, touch sensations etc. If I were to start over with this project, I would have researched more on the details of how to create things such as sound effects, touch sensations displayed through VR [15].

REFERENCES

- [1] Jerald, Jason, et al. "Developing virtual reality applications with Unity." 2014 IEEE Virtual Reality (VR). IEEE, 2014.
- [2] Lee, Unggi, et al. "Few-shot is enough: exploring ChatGPT prompt engineering method for automatic question generation in english education." *Education and Information Technologies* 29.9 (2024): 11483-11515.
- [3] Laleci, G. B., et al. "A semantic backend for content management systems." *Knowledge-based systems* 23.8 (2010): 832-843.
- [4] Wenk, Gary L. "Neuropathologic changes in Alzheimer's disease." *Journal of Clinical Psychiatry* 64 (2003): 7-10.
- [5] Blennow, Kaj, Mony J. de Leon, and Henrik Zetterberg. "Alzheimer's disease." *The Lancet* 368.9533 (2006): 387-403.
- [6] StGeorge, Jennifer, Allyson Holbrook, and Robert Cantwell. "Affinity for music: A study of the role of emotion in musical instrument learning." *International Journal of Music Education* 32.3 (2014): 264-277.
- [7] Desai, Parth Rajesh, et al. "A review paper on oculus rift-a virtual reality headset." arXiv preprint arXiv:1408.1173 (2014).
- [8] Paredes, Cristian Mauricio Gallardo, Cristian Machuca, and Yadira Maricela Semblantes Claudio. "ChatGPT API: Brief overview and integration in Software Development." *International Journal of Engineering Insights* 1.1 (2023): 25-29.
- [9] Taneja, Sheetal, and Pratibha R. Gupta. "Python as a tool for web server application development." *JIMS8I-International Journal of Information Communication and Computing Technology* 2.1 (2014): 77-83.
- [10] Song, Fei, and W. Bruce Croft. "A general language model for information retrieval." *Proceedings of the eighth international conference on Information and knowledge management*. 1999.
- [11] Prickett, Carol A., and Randall S. Moore. "The use of music to aid memory of Alzheimer's patients." *Journal of Music Therapy* 28.2 (1991): 101-110.
- [12] Peprah-Asare, Elizabeth. "Reflections on The Remember Me Project: Queen’s University’s Black Past and the AfroWomanist Sankofa Archive to Our Future." *Journal of Critical Race Inquiry* 10.2 (2023): 92-115.
- [13] Bourgeois, Michelle S. "Enhancing conversation skills in patients with Alzheimer's disease using a prosthetic memory aid." *Journal of Applied Behavior Analysis* 23.1 (1990): 29-42.
- [14] Ohser, Joachim, and Katja Schladitz. *3D images of materials structures: processing and analysis*. John Wiley & Sons, 2009.

- [15] Culbertson, Heather, Samuel B. Schorr, and Allison M. Okamura. "Haptics: The present and future of artificial touch sensation." *Annual review of control, robotics, and autonomous systems* 1.1 (2018): 385-409.