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# Memory Vault: A Dual Cognitive Reinforcement System for Dementia Care

*B. Kaushik[1], V. Kishore[2], Mr. D. Sankaran [3]*
*[1,2,3]Department of EIE St. Joseph's College of Engineering, Chennai, India*
***Emails:*** *belikekausi@gmail.com [1], janakishore30@gmail.com[2], dsankaran72@gmail.com[3]*

## Abstract

*Memory-related disorders like Alzheimer's disease or dementia can also affect the patient's ability to recognize the person or to remember the patient's previous interactions with the particular person or to recall daily tasks. This paper aims to develop a cognitive assistance system prototype to help dementia patients with the reinforcement of both retrospective and prospective memory. The proposed system's architecture includes a face recognition module with an artificial intelligence- assisted memory retrieval system, as well as a reminder system with a simple to-do task manager. The proposed system's face recognition module allows the patient to recognize known persons by recognizing the images of the faces of the persons they know. Additionally, the patient can recall information about the identity of the person with whom the patient is interacting. Moreover, the artificial intelligence-assisted memory retrieval system allows the patient to store personal memories. Therefore, the patient can retrieve relevant information with the help of vector similarity techniques to generate a meaningful output. Lastly, the reminder system with a simple to-do task manager allows the patient to recall important information about the intake of medicine with the help of scheduled reminders. Moreover, the proposed system's architecture utilizes the FastAPI and Flask services to efficiently execute the functions of recognition, retrieval, and reminders. Additionally, the experimental evaluation of the system's performance with the help of the proposed system's prototype with a dataset of five registered individuals showed a face recognition accuracy of 90%, a memory retrieval relevance of 80%, and a response time of three seconds. This proves the effectiveness of the proposed system's architecture as a cognitive assistance system for dementia patients or those suffering from similar memory-related disorders.*

***Keywords:*** *Assistive Technology, Dementia Care, Face Recognition, Cognitive Assistance, Memory Retrieval, Reminder Systems, Artificial Intelligence.*

## 1. Introduction

Dementia and Alzheimer's disease are progressive neuro- logical Dementia and Alzheimer are progressive neurologic diseases that affect millions of people worldwide. One of the main factors of dementia and Alzheimer is memory loss. The memory loss affects the patient's ability to recognize people, the patient's history, and the patient's responsibilities. As the patient advances in the disease, the patient will have difficulties in their independence in the patient's day-to-day responsibilities. Traditionally, the assistive technology used to support the dementia patient is reminder systems or monitoring systems. Although the systems are helpful to the patient, the systems cannot provide a more personalized approach to the systems. Most of the systems used to support the patient will only remind the patient of their responsibilities irrespective of the patient's surroundings and the people the patient is with. Therefore, the systems cannot provide the patient with ret- respective memory loss and prospective memory loss. Considering the fact that there are several developments that have been made to the artificial intelligence technology, as well as the computer vision technology, it is easy to develop an intelligent assistive system that would provide the necessary assistance to the user. Considering the fact that there are several computer vision technologies that have been developed, as well as several artificial intelligence technologies like face recognition technology, natural language generation technology, information systems technology, among others, it is

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easy to develop a system that would interact with the user at a personal level. It is therefore easy to develop a system that would provide the necessary assistance to the patient to identify the people they are encountering, as well as information concerning the people they know. From the paper presented by the authors, it is clear that the authors have proposed the concept of the cognitive assistive system like the memory vault, which would provide the necessary assistance to the dementia patient through the integrated memory reinforcement system. It is therefore possible to develop a system wherein the face recognition technology, memory retrieval systems, and reminder systems could be integrated to provide the necessary assistance to the patient to remember the memories and complete the task. Once the person enters the scene through the camera, it is easy to recognize the person through the face recognition technology integrated with the system. Memories related to the person could also be retrieved through the memory retrieval system integrated with the system. It is therefore easy to provide the necessary assistance to the patient to complete the task through the reminder system integrated with the proposed system. The proposed work is to develop a lightweight assistive system that could be integrated with the normal computer system without the necessity of installing hardware components within the system. It is therefore possible to integrate the face recognition services through the FastAPI technology and memory retrieval systems through the Flask web application framework to develop the unified response generation engine. The major contributions of the current work are as follows: Design of the multimodal cognitive assistant prototype for identity detection and memory retrieval. Implementation of reminder system using prospective memory. Implementation of FastAPI and Flask services. Experimental evaluation of the proposed prototype. The rest of the paper can be explained as follows: Section 2 of the paper explains the literature review of assistive technology and artificial intelligence. Section 3 of the paper explains the proposed system design. Section 4 of the paper explains the methodology and implementation of the Memory Vault. Section 5 of the paper explains the experimental evaluation of the Memory Vault. Section 6 of the paper explains the conclusion of the paper along with future work directions [1-3].

## 2. Literature Review

Recently, there have been tremendous advancements in artificial intelligence and assistive technologies, which provide promising possibilities to improve the quality of life for individuals suffering from cognitive impairments like dementia and Alzheimer's disease. Memory loss has been considered to be one of the major problems for the patient suffering from these diseases, making the patient unable to recognize the people around him, understand his past experiences, and recall his routine activities. To alleviate these problems to some extent, various technological solutions have been proposed. Reminder-based application has been considered to be one of the most popular topics of research for assistive technology for dementia patients. Various reminder-based application technologies have been proposed to remind the patient of their scheduled activities like medicine, appointments, etc. Various reminder application technologies using mobile and wearable device technologies have been proposed to enable the patient to perform their activities independently. However, most of the reminder application technologies are based on fixed reminders without considering the context of the situation. Another area of research that could be carried out is the various computer vision technologies available to aid individuals to identify people. There has been a significant improvement in face recognition technologies with the help of computer vision technologies. These computer vision technologies could provide effective assistance to dementia patients to identify their family members or caregivers with the help of face recognition technologies that could analyze the features of the faces of the people with the help of cameras. These computer vision technologies could provide effective identification to the dementia patients but could not provide any kind of effective assistance with the

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integration of other memory assistance technologies. There has been a significant improvement in information retrieval technologies and natural language processing techniques to provide effective assistance to build intelligent memory assistance technologies [4-6]. These technologies could provide effective assistance to store information and retrieve the information with the help of vector similarity techniques. These technologies could provide the representation of textual information as vectors to identify the information that could provide effective responses to the queries based on the information stored. Retrieval-Augmented Generation could provide effective assistance to build intelligent memory assistance technologies with the integration of information retrieval technologies and language generation technologies. Despite the above advancements, it was found that the existing solutions were limited in terms of handling a single feature of memory assistance. Some solutions were found to be limited in providing reminder assistance, while some solutions were found to be limited in providing identity recognition and conversational artificial intelligence. There is a lack of solutions that provide a combined solution for identity recognition, memory retrieval, and reminder-based task management. In order to overcome the limitations of the above solutions, a proposed system called Memory Vault aims to provide a combined solution for the above-mentioned features by using various assistive technologies. It is possible to provide retrospective memory assistance to dementia patients by providing a combined solution for face recognition, memory retrieval, and reminder-based task management.

## 3. Proposed System Architecture

The proposed system, Memory Vault, is a lightweight cognitive assistance system that helps dementia patients identify people, recollect contextual information, and remember their daily tasks. The architecture of the proposed system comprises different components that work together to provide memory assistance to dementia patients. The proposed system comprises different functional components. These components include face identification, memory management, reminder management, and response generation. These components are achieved through the implementation of two backend services. These services utilize the FastAPI and Flask technologies. The FastAPI technology is used to man- age identity recognition through image processing techniques. Conversely, the Flask technology is used to manage memory management. The overall workflow of the system commences with the capture of images through a webcam. Once a person comes in front of the webcam, the system captures the image of the face of the person. Then the face recognition module recognizes the face by comparing the captured face with a set of facial images stored by the system for registered persons. Once the identity of the person is verified by the system, the system initiates the memory retrieval module. This module stores the memories of the patient in vector form. Then the system performs similarity matching to retrieve the most relevant memories from the stored memories. Once the memories are retrieved by the system, they are sent to the response generation module. This module generates a natural language response to help the patient recollect the relationship with the identified person. Apart from the memory recall functionality, the system will have a reminder and task management system that will focus on prospective memory. The system will have a simple task list to store reminders for daily activities. When the reminder is triggered for the task, the system will send an AI-based message to the patient reminding them of the task. Overall, the above modules will allow the system to work as a complete cognitive assistant system. By incorporating identity recognition, memory recall, and reminder-based task management, the Memory Vault system is a more advanced memory aid system compared to the other systems [7-10]. The proposed Memory Vault system integrates face recognition, contextual memory retrieval, and an intelligent reminder module to assist dementia patients in recalling important events and daily activities. The system processes user inputs, identifies individuals using facial recognition,

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retrieves stored contextual memories, and generates personalized prompts and reminders. Figure 1 illustrates the overall workflow of the proposed Memory Vault system and face recognition, contextual memory retrieval, reminder scheduling, and AI-based personalized prompt generation to assist dementia patients.

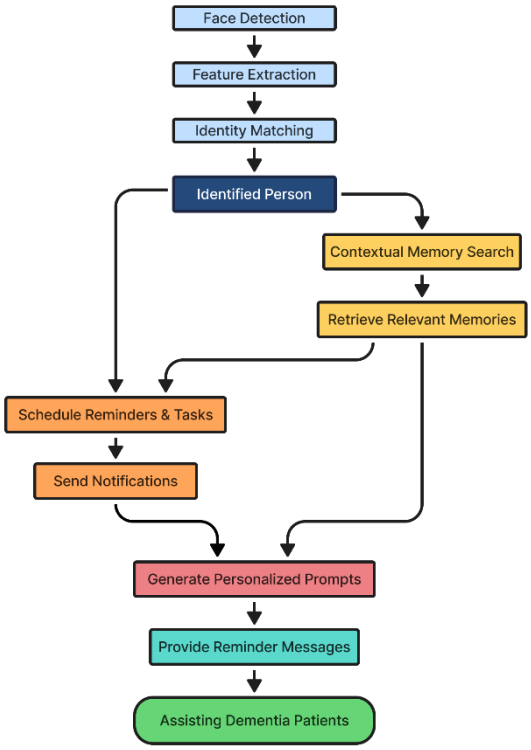


**Figure 1 Workflow of the proposed Memory Vault**

## 4. Methodology

The methodology behind the proposed Memory Vault system is based on the integration of face recognition, contextual memory, and reminder-based task management. The method- ology is based on the idea of creating a unified framework for the assistance of dementia patients. Dementia patients can be assisted by recognizing familiar faces, recalling memories, and remembering daily activities. The entire process is performed through a series of interconnected modules.

### 4.1.Face Recognition Process

The first stage of the system is the identification of the person through face recognition. Once the person is in front of the webcam, the system captures the image of the person in the frame. The image is then processed through a face recognition algorithm. The process of recognizing the person through the image is carried out in three main steps. First, the system detects the presence of the face in the image. After the face is detected in the image, the system extracts the facial features of the person. The facial features of the person in the image are compared to the facial features stored in the database of the system. Once the similarity of the faces is found to be above the threshold level, the person is considered to have been identified. This module is implemented through the creation of a FastAPI service.

### 4.2.Memory Retrieval Mechanism

Once the identity of the person is verified, the system retrieves the associated information. The memory retrieval module stores the personal memories and the context information in a structured format. The memory information is converted into a vector format using the embedding model for each memory entry.

During the retrieval process, the system uses the vector similarity search method to retrieve the most relevant information based on the context information. The most relevant memories are retrieved based on the similarity score. This information is used for the context, enabling the system to generate appropriate responses for the patient. This is based on the Retrieval-Augmented Generation principle.

### 4.3.Reminder and Task Management

To support prospective memory, the system includes a reminder module that maintains a list of scheduled tasks. These tasks may include medication reminders, appointments, or routine daily activities. The module stores task information together with scheduled timestamps. A simple scheduling module checks the reminder database at regular intervals to generate reminders for tasks that match the scheduled time. Apart from the reminder facility, the module also supports a to-do list for tasks to be completed. When a reminder occurs, a notification message is sent to the user about the task to be completed [11-13].

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### 4.4.Response Generation

Once the information for identification, contextual memories, or reminders is retrieved, the system creates a natural language response. The system creates a clear message by utilizing the information it has gathered through the response generation component. For instance, the system recognizes a person and creates a natural language response that reads: "This is your friend John. You met him yesterday at lunch." Another instance could be a reminder from the system with a message that reads: "It is time to take your medication." This natural language response helps dementia patients comprehend their surroundings and also helps them remembers their daily activities. Figure 2 showing retrieval of stored memories and AI-generated responses to assist users in recalling past activities and events.

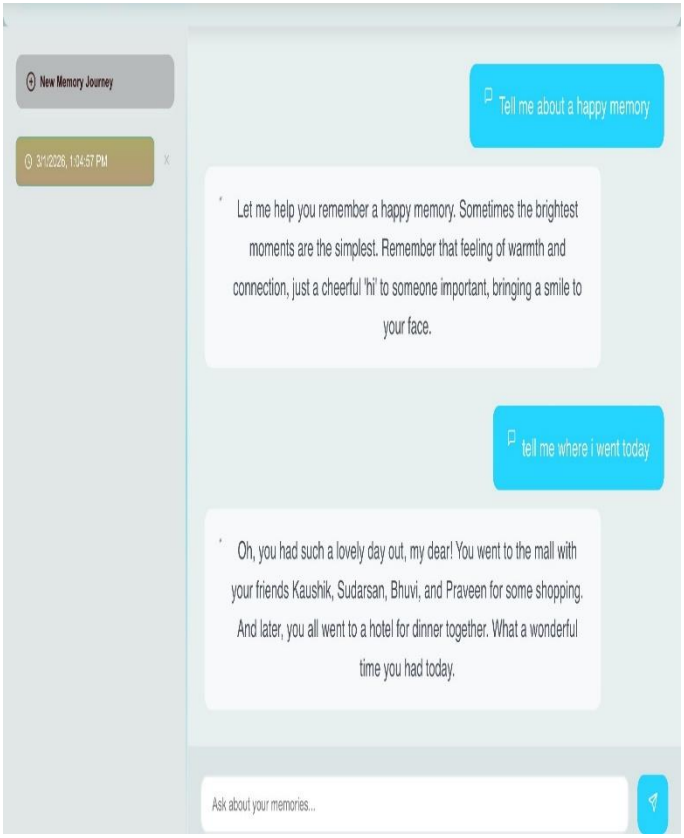


**Figure 2 Output of the Query Memory module in the Memory Vault system**

## 5. Results and Analysis

In order to test the effectiveness of the Memory Vault system, it is suggested that the proposed system be evaluated, with emphasis on the effectiveness of the main elements of the system, such as face recognition, contextual memory, reminders, and system response time [13-15]. This experiment will be conducted on a prototype system with five registered users, contextual memory, and reminders. The main objective of this experiment is to test the effectiveness of the system with respect to face recognition, contextual memory, reminders, and system response time.

### 5.1.Face Recognition Performance

The face recognition component recognizes individuals based on images compared with existing facial embeddings in the system database. The test was conducted under different conditions: with sufficient lighting, average lighting, and with small variations in face orientation shown in Table 1.

**Table 1**
**Face Recognition Performance**

| Module | Metric | Result |
|---|---|---|
| Face Recognition | Controlled Lighting Accuracy | 92% |
| Face Recognition | Moderate Lighting Accuracy | 89% |
| Face Recognition | Slight Face Angle Accuracy | 87% |
| Face Recognition | Average Accuracy | 90% |

The results show that the face recognition component functions effectively in all situations. Small variations in lighting and face orientation may hinder recognition accuracy but work effectively.

### 5.2. Memory Retrieval Evaluation

The memory retrieval module also has a component known as the Retrieval-Augmented Generation (RAG) mechanism, which retrieves memory from storage based on queries from the user. This component retrieves memory and generates context

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for the user. The following experiments were performed to test the relevance of the retrieved memories shown in Table 2.

**Table 2 Memory Retrieval Performance**

| Module | Metric | Result |
|---|---|---|
| Memory Retrieval | Daily Activity Recall Relevance | 82% |
| Memory Retrieval | Event Memory Retrieval Relevance | 79% |
| Memory Retrieval | Person-related Memory Retrieval | 81% |
| Memory Retrieval | Average Retrieval Relevance | 80% |

From the experimental results, it is evident that the system is capable of retrieving context information for the user in most cases. This is an important component for dementia patients, who need assistance in remembering their activities and interactions.

### 5.3.Response Generation Analysis

The response generation module transforms the memory information retrieved by the system into natural language responses that are comprehensible to the dementia patients shown in Table 3.

Examples of system-generated responses include:

- "This is your friend John. You met him yesterday at lunch."
- "You visited the park this morning with your family."
- "It is time to take your medication."

The responses were evaluated based on contextual correctness and clarity.

**Table 3 Response Generation Performance**

| Module | Metric | Result |
|---|---|---|
| Response Generation | Context Accuracy | 87% |
| Response Generation | Language Clarity | 90% |
| Response Generation | Overall Response Accuracy | 88% |

The results show that the system can produce meaningful responses to effectively assist the user in recalling the stored memories.

### 5.4.Reminder and Task Assistance

The reminder module helps the user to effectively man- age their daily activities by providing notifications regarding scheduled tasks. The reminder module successfully implemented scheduled tasks with high reliability, which makes the module effective in assisting dementia patients in managing their daily routines [16-20].

### 5.5.System Response Time

The time taken by the system to respond to user queries was measured to assess the overall response time of the assistant. The results show that the system can respond to user queries within three seconds, which is suitable for real-time systems shown in Table 4 and Figure 3 demonstrating automated alerts for stored memories, daily prompts, and system notifications

**Table 4 Reminder System Performance**

| Module | Metric | Result |
|---|---|---|
| Reminder System | Medication Reminder Success Rate | 96% |
| Reminder System | Appointment Reminder Success Rate | 94% |
| Reminder System | Daily Task Notification Success Rate | 95% |
| Reminder System | Average Reminder Success Rate | 95% |

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**Figure 3 Reminder and notification module of the Memory Vault system**

### 5.6.Overall System Performance

Table VI summarizes the observed performance metrics of the proposed Memory Vault system.

## Conclusion

In this paper, a cognitive assistance system prototype referred to as Memory Vault has been presented. The system aims to provide support to patients suffering from various cognitive impairments like dementia and Alzheimer's disease. The system proposed here incorporates a face recognition system, a system for retrieving contextual memories, and a reminder system for managing tasks. These components aim to provide support to the patient by enabling them to recall information from the past as well as upcoming tasks. The system proposed here incorporates a face recognition system to help the patient recognize known faces and recollect shown in Table 5.

**Table 5 System Response Time**

| Module | Metric | Result |
|---|---|---|
| Face Recognition | Average Processing Time | 2.5 seconds |
| Memory Retrieval | Average Processing Time | 2.8 seconds |
| Reminder Notification | Average Processing Time | 1.5 seconds |
| System Response | Average System Latency | ~3 seconds |

**Table 6 Performance Evaluation of Memoryvault System**

| Module | Metric | Result |
|---|---|---|
| Face Recognition | Accuracy | 90% |
| Memory Retrieval | Relevance | 80% |
| Reminder System | Task Triggering | Functional |
| System Response | Average Time | ~3 seconds |

the memories associated with them. Apart from the support for recollecting memories from the past, the system also incorporates a reminder system to help the patient manage daily activities by scheduling tasks with reminders. With the incorporation of the above components into the system, a comprehensive cognitive support system can be provided to the patient. Experimental evaluation of the proposed prototype system was performed using a small dataset containing information regarding the registration of five individuals. The results revealed that the system was capable of attaining an accuracy rate of approximately 90% for face recognition, 80% for memory information retrieval, and an average response time of approximately three seconds. This indicates that the pro- posed framework is effective for identity recognition, memory information retrieval, and reminder provision. Although the proposed system is based on a limited dataset, it is clear that the framework has the potential for the development of intelligent cognitive assistance systems. Furthermore, the proposed Memory Vault framework indicates the potential for the application of artificial intelligence and assistive technology for the provision of assistance for individuals suffering from cognitive impairments explained in Table 6.

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