Monitor Alzheimer's symptoms using cognitive activities

Alzheimer’s Care and AI-Based Support Systems

Mendis A.R.P.

IT21228094

B.Sc. (Hons) Degree in Information Technology
Specializing Information Technology

Department of Information Technology

Sri Lanka Institute of Information Technology
Sri Lanka

April 2025

Monitor Alzheimer's symptoms using cognitive activities

Alzheimer’s Care and AI-Based Support Systems

Mendis A.R.P.

IT21228094

B.Sc. (Hons) Degree in Information Technology

Specializing Information Technology

Department of Information Technology

Sri Lanka Institute of Information Technology

Sri Lanka

April 2025

DECLARATION

I declare that this is my own work and this dissertation1 does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

Also, I hereby grant to Sri Lanka Institute of Information Technology, the nonexclusive right to reproduce and distribute my dissertation, in whole or in part in print, electronic or other medium. I retain the right to use this content in whole or part in future works (such as articles or books).

Name	Student ID	Signature
MENDIS A.R.P.	IT21228094	

The supervisor/s should certify the proposal report with the following declaration.

The above candidate has carried out research for the bachelor's degree Dissertation under my supervision.

……………………………… ………………………………

Mrs. Uthpala Samarakoon Date

Supervisor

ACKNOWLEDGEMENT

I would like to express my deep appreciation to the individuals and institutions that have been instrumental in the successful completion of my research. First and foremost, I am profoundly grateful to my research supervisor, Mrs. Uthpala Samarakoon, and co-supervisor, MS. Poorna Panduwawala, for their invaluable guidance and unwavering support throughout my research journey on the topic of the Alzheimer's disease . Their expertise and insightful discussions have been pivotal in shaping the direction of this dissertation. They provided constructive feedback, expert advice, and direction whenever needed, ensuring the quality and depth of the research. Also like to extend my heartfelt appreciation to Lecturer Mr. Kavinga Abeywardena, Panel Head Ms. Uthpala Samarakoon, and her panel for their mentorship and encouragement. The Faculty of Computing staff also deserves recognition for their continuous support and providing access to essential resources, which significantly contributed to the project's success.

The Sri Lanka Railway Department and its dedicated staff played a pivotal role in this research by providing crucial data and insights. I express my sincere thanks to the General Manager of Railways, Mr. W.A.D.S.Gunasinghe and the Head of Tickets at Maradana Station, Mr. Mangala, for their support and willingness to share their extensive knowledge. Furthermore, I would like to acknowledge the valuable contributions of my fellow group members, Mr. Janith Dilshan, Ms. Janani Nawodha, and Ms. Achini Madurika. Their collaborative efforts and dedication significantly contributed to various aspects of the research.

Finally, I would like to express my gratitude to all the other individuals and institutions, both mentioned and not mentioned, who have contributed to this research in various ways. Their assistance has been immensely valuable in making this thesis successful.

Abstract

Alzheimer's disease is a progressive neurological condition that severely impacts memory, communication, and cognition. Its early and accurate determination of stages is important for its effective care planning, intervention, and management. This paper presents the design and development of a mobile app based on artificial intelligence (AI) for the identification of the clinical stage of Alzheimer's disease based on the Global Deterioration Scale (GDS). The proposed solution integrates two machine learning models: one for speech analysis and recognition and another for facial emotion detection.

The app features an interactive assessment interface where the patients respond to five clinically relevant questions via microphone and camera. Using speech-to-text, the speech module identifies key linguistic features like speech rate (WPM), pauses, fillers, and repetition patterns. Meanwhile, the vision module identifies emotional states like confusion or normal behavior via facial expression recognition. These multimodal inputs are analyzed, and the patients are classified into three broad cognitive stages: Pre-Dementia (GDS stages 1–3), Mild to Moderate Dementia (GDS stages 4–5), and Severe Dementia (GDS stages 6–7).

The application provides real-time diagnostic feedback and additionally maintains a history log for tracking cognitive development over time. It empowers caregivers and clinicians by providing access to intuitive, AI-driven insights into the cognitive health of Alzheimer's patients. This solution bridges the gap between home-based monitoring and clinical diagnosis, particularly in low-resource settings. The research also includes a validation phase through accuracy testing, usability testing, and adherence to clinical standards. Overall, the project demonstrates the potential of AI-driven mobile health solutions in fostering early detection, continuous monitoring, and improved care for Alzheimer's disease patients.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF ABBREVIATIONS

Abbreviation	**Description**
ML	Machine Learning
GDS	Global Deterioration Scale
WHO	World Health Organization
AD	Alzheimer's disease
NLP	Natural Language Processing
CNN	Convolutional Neural Network
WPM	Words Per Minute
AI	Artificial Intelligence
UI	User Interface
UX	User Experience

1. INTRODUCTION

1.1. Background & Literature Survey

Cognitive games have emerged as effective tools for enhancing and assessing mental functions, particularly in domains such as memory, attention, and problem-solving. These games are increasingly being integrated into both clinical and educational environments to support cognitive training and facilitate early diagnosis of neurodegenerative conditions such as Alzheimer's disease. Among the diverse range of cognitive games, two notable approaches stand out: interactive drawing-based tasks and personalized puzzle-solving games. [1] [2]

One innovative method involves a drawing task where a random image is displayed, and users are prompted to replicate it on a writing board. The system evaluates the drawing in real time using artificial intelligence. If the image is replicated with sufficient accuracy, the system marks it as "Correct" and moves to the next image. Otherwise, [2] [3]the message "Incorrect" is shown, allowing for correction or retry. Drawing tasks like these assess users' visuospatial abilities, semantic memory, and motor coordination—skills that are often affected in the early stages of cognitive decline. The Clock Drawing Test (CDT), for instance, has been widely used for cognitive screening and remains a benchmark in assessing drawing-based cognitive performance. [1]

Complementing drawing games, personalized family photo puzzles offer a deeply engaging cognitive intervention. In this method, caregivers upload family photos, which are then segmented into puzzles that users must reconstruct. This interactive task stimulates autobiographical memory recall, visual recognition, and emotional engagement [3]critical areas affected in individuals with dementia. Reminiscence therapy studies have shown that familiar visual cues can significantly improve memory recall and mood in dementia patients [2]

Recent advancements in deep learning and computer vision have enabled real-time, accurate interpretation of hand-drawn input and personalized content through technologies such as convolutional neural networks (CNNs). These innovations facilitate the development of adaptive, intelligent cognitive games capable of delivering therapeutic and diagnostic value. Automated sketch recognition and personalized puzzle interfaces can enhance engagement while providing meaningful insight into cognitive health [3]

This project integrates both approaches—drawing recognition and family photo puzzle reconstruction—into a unified AI-assisted cognitive game. The goal is to deliver a rich, interactive experience that not only supports mental stimulation and memory enhancement but also acts as a potential early diagnostic aid for individuals in the early to moderate stages of dementia or Alzheimer's disease [4]

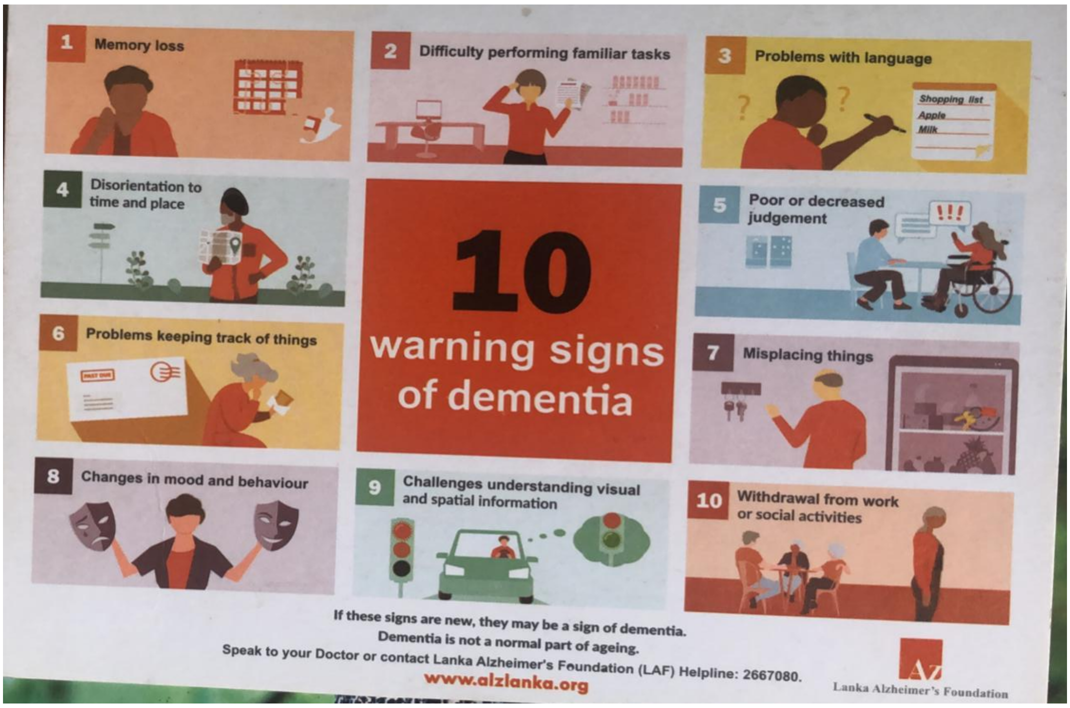

Figure 1- warning signs of dement

1.2. Research Gap

Numerous cognitive training systems and digital therapies have been developed to aid individuals experiencing memory and cognitive decline, particularly those in the early to moderate stages of Alzheimer's disease. However, a comparison with the proposed system reveals a substantial research gap after evaluating several existing studies. While current research often focuses on single aspects such as puzzle-solving or drawing-based tasks, they typically lack integration, real-time AI-based assessment, personalized content, and multi-functional feedback mechanisms.

Three categories of prior research can be identified:

- Drawing-based cognitive tasks, which present users with predefined or structured images to replicate, often evaluated manually or with minimal automation [1]
- Generalized puzzle games, which do not incorporate emotionally resonant or personalized content [3]
- Mobile cognitive apps, which may lack real-time AI feedback, customization, or integration of multiple therapeutic elements in a cohesive experience [5].

Despite their individual strengths, these systems fail to address critical areas such as:

- Randomized drawing recognition with AI for evaluating visual memory and motor coordination [1]
- Emotionally significant content, such as family photo puzzles, to stimulate autobiographical memory [2] [4]
- Home-accessible cognitive monitoring through a unified platform [3],
- Real-time, adaptive feedback to enhance engagement and therapeutic response [1]

The proposed system uniquely combines all these missing elements: it integrates AI-powered sketch evaluation, personalized puzzles using caregiver-uploaded family photos, and a gamified interface that is both therapeutic and diagnostic. This holistic approach stands apart from earlier systems by fostering emotional engagement, delivering multi-modal cognitive stimulation, and providing accessible tools for caregivers and therapists alike.

Application Reference	Randomized Drawing Task with	Personalized Puzzle Content	Real-Time Feedback & Evaluation	Emotional Relevance (e.g., family photos)	Home-Accessible Platform	Gamified User Interface
Research A	✓	✗	✗	✗	✗	✗
Research B	✗	✗	✗	✗	✓	✓
Research C	✓	✗	✓	✗	✗	✗
Proposed System	✓	✓	✓	✓	✓	✓

Table 1.1.1 Research gap

Therefore, this research gap highlights the need for cognitive platforms that combine drawing, personalization, real-time analysis, and emotional relevance. Addressing these gaps may lead to more effective and accessible cognitive therapies, especially for individuals living at home or in assisted care settings

Research A [1]focuses on hand-drawn sketch recognition but lacks personalization, emotional engagement, and a gamified interface.

Research B [3] [5] emphasizes general cognitive stimulation games but does not support AI-based analysis or emotionally relevant content.

Research C [5] [6] includes AI-powered evaluation but neglects user personalization and engagement design.

The Proposed System integrates all critical features: AI drawing analysis, personalized puzzle therapy (using family photos), real-time feedback, emotional engagement, home accessibility, and gamified UX—addressing the gaps found across all previous works.

1.3. Research Problem

Despite advancements in digital cognitive tools, existing systems often fail to deliver a comprehensive therapeutic solution that addresses both the emotional and cognitive needs of individuals experiencing early to moderate stages of Alzheimer’s disease. Current approaches typically isolate key components such as drawing tasks, puzzle games, or feedback systems rather than integrating them into a unified platform. Most notably, there is a lack of systems that incorporate randomized drawing recognition, personalized puzzle-based therapy using family photos, and real-time AI-driven feedback, all of which are critical for improving cognitive engagement and memory recall.

Moreover, emotionally significant stimuli, which are shown to stimulate autobiographical memory and foster deeper user engagement, are often neglected in existing systems. Personalized content, such as family photographs, remains underutilized in both diagnostic and therapeutic contexts. At the same time, systems that do provide cognitive assessments often require clinical supervision and are not designed for continuous, home-based use—limiting their accessibility and long-term impact.

Thus, the research problem lies in the absence of a holistic, AI-powered cognitive platform that combines:

- Visual drawing replication tasks evaluated in real time,
- Personalized puzzle games using emotionally meaningful content,
- Home-accessible mobile implementation, and
- A gamified interface to increase motivation and participation.

Without addressing this gap, individuals in the early stages of cognitive decline may miss critical opportunities for timely intervention, engagement, and monitoring ultimately affecting the progression and management of their condition.

1.4. Research Objectives

1.4.1. Main Objective

The main objective of this project is to design and develop a mobile-based cognitive therapy application that leverages interactive activities and personalized content to support individuals with early to moderate stages of Alzheimer's disease. The system aims to enhance cognitive abilities such as memory, attention, and recognition through engaging tasks like drawing replication and puzzle-solving.

This mobile application is intended to function as both a therapeutic aid and a monitoring tool, helping users maintain mental activity in a home environment while allowing caregivers or therapists to track progress and customize therapy accordingly.

To achieve this, the system integrates:

- Randomized image-based drawing tasks to assess visual recognition and motor coordination
- Personalized puzzles generated from uploaded family photos to stimulate autobiographical memory
- Real-time feedback mechanisms to guide users and reinforce engagement
- A gamified, elderly-friendly interface to encourage consistent use
- t-home usability through mobile accessibility
- Caregiver/therapist involvement for customizing therapy and validating user progress

The overall goal is to provide a holistic, user-friendly, and adaptive solution that improves the quality of cognitive care for individuals affected by Alzheimer's, making therapy more accessible, effective, and emotionally supportive.

1.4.2. Specific Objectives

To implement randomized image-based drawing tasks

This objective focuses on enabling users to engage with a drawing-based cognitive activity, where they are prompted to replicate randomly displayed images on a digital drawing board within the mobile application. This activity is designed to stimulate visual recognition, memory recall, attention span, and motor coordination—skills that often decline in individuals with Alzheimer's disease

To develop a personalized puzzle module

This objective focuses on the design and implementation of a personalized puzzle feature within the mobile application, specifically aimed at enhancing memory recall, emotional connection, and cognitive stimulation in individuals experiencing cognitive decline, such as those in the early to moderate stages of Alzheimer's disease.

The use of family photos adds a deeply personal and emotionally meaningful element to the therapy process. Familiar images can help trigger autobiographical memory, encouraging users to recall people, places, and events from their past an approach that aligns with evidence from reminiscence therapy in dementia care.

To integrate real-time feedback mechanisms

that assess user performance and provide adaptive guidance throughout the cognitive tasks. This objective involves the implementation of real-time feedback features within the mobile application to monitor the user's performance and deliver instant, adaptive responses during cognitive activities such as drawing and puzzle-solving. The goal is to enhance user engagement, motivation, and learning outcomes by providing continuous support and encouragement throughout therapy sessions.

To design a gamified, elderly-friendly mobile interface

that encourages consistent use through visually engaging, easy-to-navigate design.

This objective focuses on creating a **user interface (UI)** specifically tailored to meet the needs of elderly users particularly those with cognitive decline by combining **simplicity, clarity, and motivation-enhancing elements**. The goal is to make the mobile application not only functional but also enjoyable and easy to use, thereby encouraging regular participation in therapeutic activities.

Figure 2- Data gathering from Alzheimer's foundation

To enable at-home usability

by making the system accessible on mobile devices, allowing caregivers to manage therapy and track progress remotely.

This objective emphasizes the importance of accessibility, independence, and remote monitoring by ensuring that the entire cognitive therapy system is mobile-based and can be conveniently used in home environments. It focuses on delivering effective care outside clinical settings reducing dependency, lowering cost, and encouraging routine cognitive stimulation for individuals with Alzheimer’s or cognitive decline.

To involve medical or therapeutic experts in the system

by allowing custom task recommendations and validation of user progress.

This objective ensures that the system is not only user-friendly for patients and caregivers but also clinically relevant and professionally guided. By integrating features that allow medical professionals and therapists to actively contribute, the system aligns more closely with therapeutic best practices and personalized care.

2. METHODOLOGY

The development of this AI-based cognitive therapy mobile application adopts a user-centered, modular, and iterative approach to ensure it meets the practical needs of both patients and healthcare professionals. The methodology combines modern software engineering principles with clinical insights from Alzheimer’s care specialists to produce a solution that is both technically robust and therapeutically meaningful.

User-centered design means that the system is built around the needs, limitations, and preferences of its primary users individuals with cognitive decline, their caregivers, and therapists. Every feature, from the interface to the task flow, is designed to be simple, accessible, and engaging, especially for elderly users.

A modular approach ensures that the system is broken into independent yet interconnected components (e.g., drawing tasks, personalized puzzles, feedback system, caregiver module). This structure improves scalability, makes testing easier, and allows future enhancements without disrupting the whole system.

The iterative development process follows a cycle of designing, building, testing, and refining the app. Feedback from real users such as therapists, caregivers, and patients—is continuously integrated into the system to improve usability, performance, and therapeutic value.

This blend of software development best practices and clinical guidance ensures the system not only functions effectively from a technical standpoint but also aligns with real-world therapeutic needs in Alzheimer’s care. As a result, the application can be reliably used for daily cognitive support, progress tracking, and personalized therapy in home settings or under caregiver supervision.

2.1. Requirement Gathering and Analysis

To further develop an understanding of the research topic and identify the current gaps, we personally met Mrs. Susan Fernando at the Lanka Alzheimer's Foundation in Maradana, Sri Lanka. The visit provided an opportunity for us to connect directly with a person who is closely involved with Alzheimer's patients and made us understand the applied importance and real-life application of our research.

To gain firsthand information regarding the needs and concerns of individuals afflicted with Alzheimer's disease, a visit to the Lanka Alzheimer's Foundation (LAF) was conducted, as it is a prominent organization providing care, support, and advocacy for Alzheimer's patients and caregivers. During the visit, valuable input was gained through discussions with staff members, caregivers, and volunteers who work directly with patients.

2.1.1. Primary Data Gathering and Analysis

Primary data were collected by:

The primary data gathering and analysis phase was essential to understanding the real-world needs and expectations of end-users. Through interviews, surveys, observations, and focus groups, valuable insights were collected from key stakeholders—such as Alzheimer's patients, caregivers, therapists, fleet operators, and drivers.

The analysis revealed critical requirements like simplicity, personalized content, and real-time tracking features. These insights guided the design of user-friendly, functional systems tailored to the cognitive therapy and fleet management domains. The findings ensured that the solution was not only technically sound but also practically rele

2.1.2. Secondary Data Gathering and Analysis

Secondary data gathering and analysis involves collecting and analyzing information from **existing sources** such as academic journals, industry reports, case studies, government publications, and previously conducted research. This process provides valuable context, supports the validation of primary data, and helps in identifying **best practices, gaps, and design standards** relevant to the project.

This phase was crucial in shaping the foundation of the proposed system by offering **evidence-based insights** into how similar systems have been implemented, what challenges they faced, and what technological solutions proved most effective.

2.2. Feasibility Study

A feasibility study is conducted to assess whether the proposed system can be practically developed, implemented, and maintained within the constraints of time, budget, technology, and user requirements. It is a crucial step in ensuring that the project is viable, cost-effective, and aligned with real-world needs. This feasibility study examines the system from six key perspectives: technical, operational, economic, legal, schedule, and security

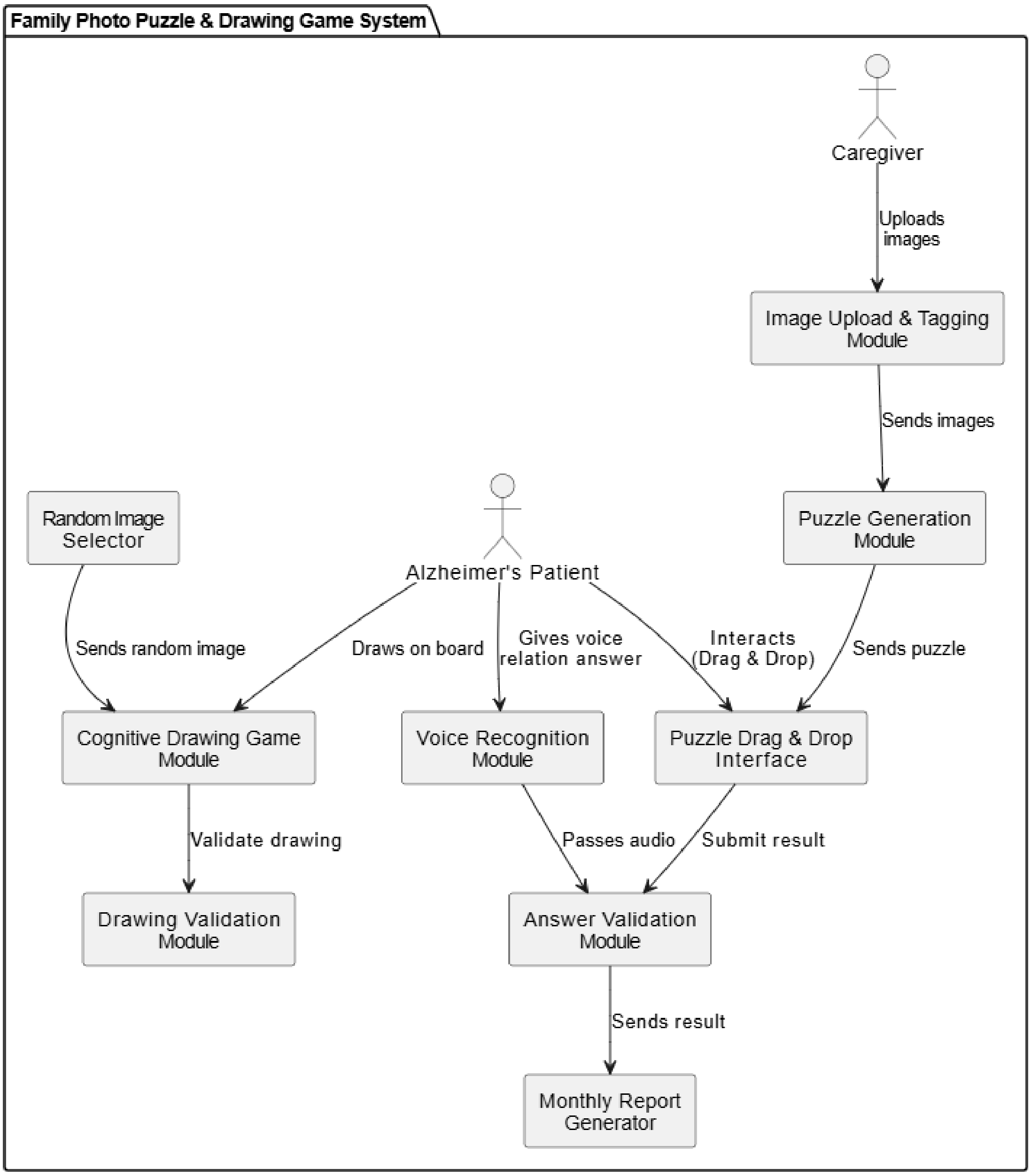

Figure 3-Component Diagram(Monitor Alzheimer's symptoms using cognitive activities.)

2.2.1. Technical Feasibility

The proposed system is technically feasible using current development tools and technologies. The project will be developed using **Flutter** for cross-platform mobile development and integrated with **Firebase** for cloud-based authentication, storage, and real-time data handling. Technologies like **OpenCV** and **TensorFlow Lite** (for image processing or AI functionalities) are lightweight and compatible with mobile devices. No specialized or experimental technology is required, making the system robust and achievable with available resources.

Hardware and Software Resources

The proposed mobile application is designed to function on common Android and iOS handsets without any bespoke hardware. Most existing handsets already contain a microphone and front-facing camera, which can suffice for capturing good quality speech and facial expression information. The application also uses light machine learning models that are locally embedded or served using cloud APIs, which makes the system feasible on medium-range mobile phones.

The software components are:

- Mobile App Framework: Flutter or React Native for cross-platform development.
- ML Frameworks: TensorFlow Lite for on-device inference or Python-based server-hosted models.
- Database: Firebase for real-time storage and analytics.
- APIs: Google Speech-to-Text or other open-source NLP models for transcription.

2.2.2. Economic Feasibility

The economic analysis shows that the development and deployment costs are reasonable, especially considering the use of free or low-cost development tools (e.g., Flutter, Firebase's free tier). In healthcare scenarios, the app reduces caregiver workload and improves therapy outcomes, offering significant value for minimal investment. In fleet management, cost savings are expected through improved maintenance planning and operational efficiency. Long-term savings outweigh the initial development cost, making the project economically viable.

Cost Considerations

Understanding and managing the **cost structure** of the proposed system is critical to ensuring its financial feasibility, scalability, and long-term sustainability. The **cost considerations** include all anticipated expenses related to system development, deployment, maintenance, and potential commercialization. By strategically selecting cost-effective tools and platforms, the project minimizes financial barriers while still delivering a high-quality solution.

Benefit Analysis

The Benefit Analysis evaluates the tangible and intangible advantages provided by the proposed system to its key stakeholders, including users, caregivers, administrators, and the wider community. The goal of the system is not only to introduce technical innovation but also to solve real-world problems, improve efficiency, and enhance quality of life.
This section highlights the expected therapeutic, economic, operational, and social benefits of the project once implemented and used consistently.

2.2.3. Operational Feasibility

Operational feasibility assesses how effectively the proposed system can function in its intended environment and how well it addresses user needs in daily practice. It evaluates whether the system will be accepted, adopted, and sustained by its users—including patients, caregivers, healthcare professionals, or system operators—based on its ease of use, practical benefits, and integration with existing routines.

User Accessibility

User Accessibility refers to the design and functionality of the system to ensure that it can be effectively used by all intended users, including those with cognitive, visual, motor, or age-related limitations. For this project, special attention has been given to making the application inclusive and user-friendly, particularly for elderly individuals with Alzheimer’s disease, as well as caregivers and therapists who assist them.

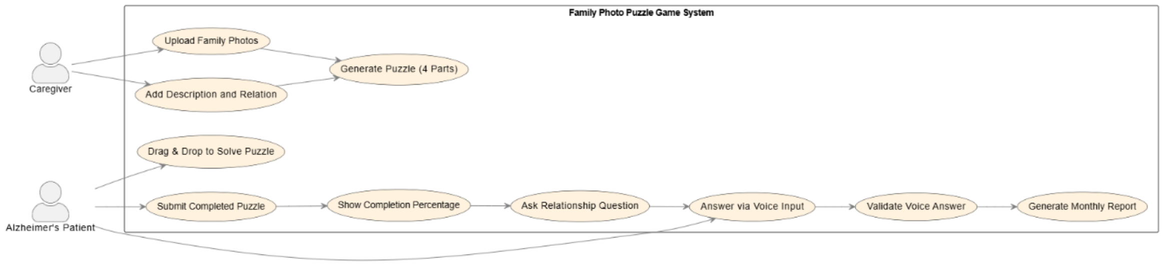

Figure 4- use case diagram(Monitor Alzheimer's symptoms using cognitive activities

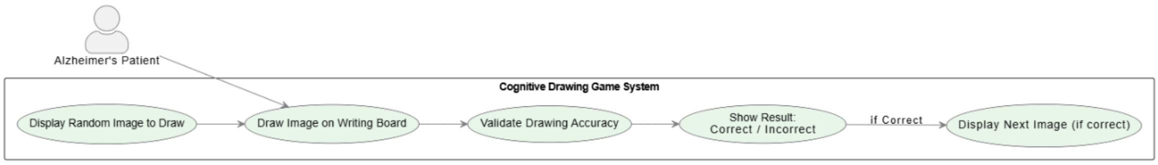

Figure 5- use case diagram(Monitor Alzheimer's symptoms using cognitive activities)

Stakeholder Readiness

Stakeholder readiness refers to the extent to which key participants—such as patients, caregivers, therapists, developers, and institutional partners—are prepared, willing, and equipped to adopt and support the system. Ensuring stakeholder readiness is critical for the successful implementation, acceptance, and long-term sustainability of the project.This section evaluates readiness across multiple stakeholder groups based on engagement, awareness, training, and technological capacity.

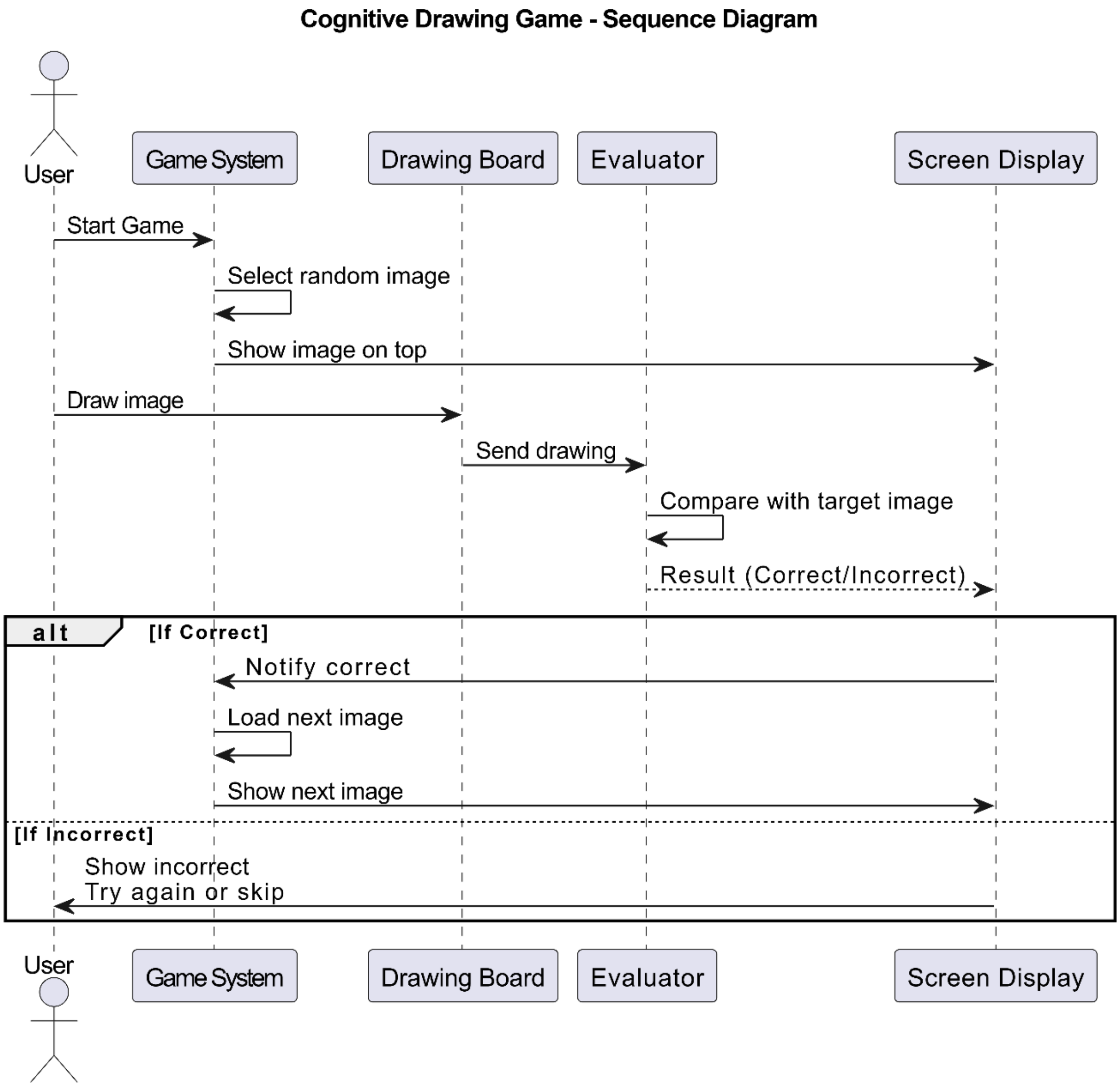

Figure 6- use case diagram(Monitor Alzheimer's symptoms using cognitive activities

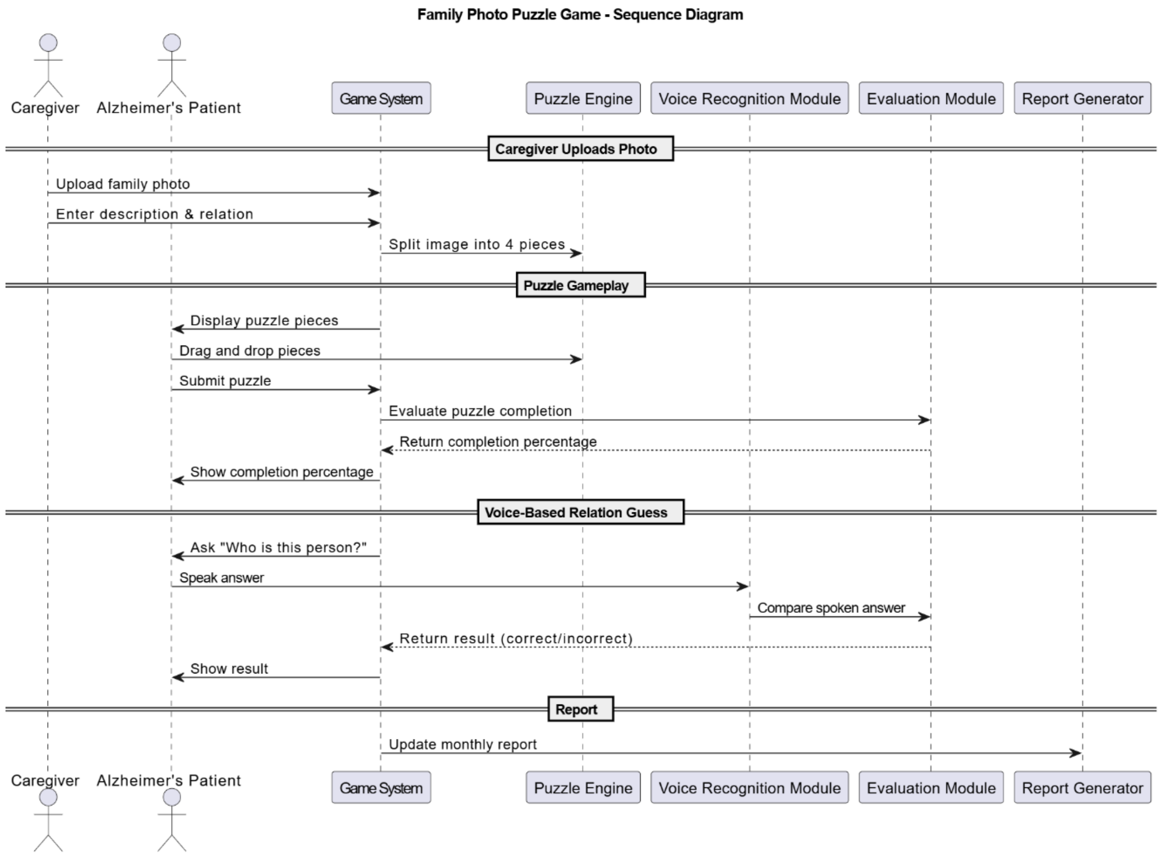

Figure 7- use case diagram(Monitor Alzheimer's symptoms using cognitive activities

Support and Maintenance

Support and Maintenance are critical components in ensuring the long-term reliability, usability, and scalability of the system after its initial deployment. For a user-sensitive application such as an AI-Based Cognitive Support Mobile App, these services are especially important to maintain performance, security, and user satisfaction over time.

This phase ensures that any technical issues, user concerns, or system enhancements are addressed promptly and efficiently.

2.2.4. Legal and Security Feasibility

The Legal and Security Feasibility study assesses whether the proposed cognitive therapy mobile application complies with relevant laws and data protection regulations, and whether adequate security measures are in place to protect sensitive user information. Given that the system deals with personal health data and family photos, ensuring legal compliance and strong data security is critical for ethical, clinical, and practical deployment.

Data Privacy Regulations

The system must comply with regulations such as:

- GDPR (General Data Protection Regulation) for users in the European Union
- HIPAA (Health Insurance Portability and Accountability Act) if deployed in healthcare settings in the United States

These laws require user consent, data encryption, secure access control, and the ability for users to review and delete their data.

Security Controls

Security controls are essential mechanisms put in place to protect user data, prevent unauthorized access, and ensure compliance with legal and ethical standards. Given that the system handles sensitive information such as patient identities, therapy progress, and personal media (e.g., family photos), robust security measures are implemented at every level of the application's architecture.

These controls are categorized into technical, administrative, and physical safeguards, ensuring end-to-end protection of the mobile application and its backend systems.

Ethical Implications

Developing and deploying a digital solution for Alzheimer's care involves significant ethical responsibilities, especially when the users include elderly individuals with cognitive impairments. The system must be designed not only to serve its technical and therapeutic functions but also to uphold the dignity, rights, privacy, and autonomy of all stakeholders. This section outlines the ethical considerations that have been addressed throughout the development of the AI-Based Cognitive Support Mobile App.

2.3. System Implementation & Design

The **System Implementation & Design** phase focuses on the technical realization of the proposed mobile application. This phase covers the translation of user requirements and therapeutic goals into a fully functional system using modern mobile development frameworks, AI technologies, and secure cloud services.

The system is designed with a **modular, scalable, and user-centric architecture**, ensuring performance, accessibility, and ease of future enhancements.

System Architecture Overview

The app architecture follows a **client-server model**, using **Flutter** for the front end (mobile interface) and **Firebase** for backend services. Key components include:

- **Frontend (Flutter)**: Provides cross-platform compatibility (Android/iOS), responsive UI, and real-time user interaction.
- **Backend (Firebase)**: Handles authentication, cloud database (Firestore), and media storage for family photos and task results.
- **AI Modules** (optional): Implemented using **TensorFlow Lite** for drawing recognition and task feedback processing.

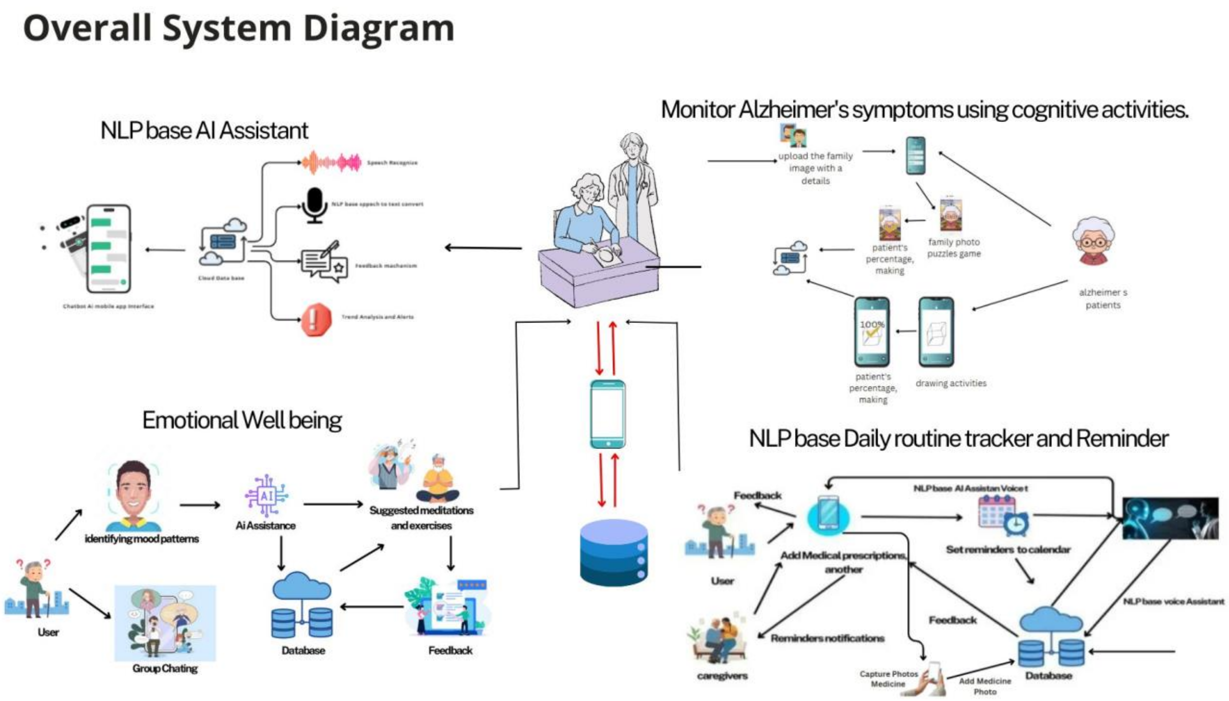

Figure 8- overall system digram

Mobile Application (Frontend)

The app is coded with Flutter to ensure cross-platform compatibility on Android and iOS. It supports a simple interface with big font sizes, navigation simplicity, and multi-language support to serve senior users. The central feature of the app is the "Cognitive Stage Identifier," which starts an assessment session with the real-time camera and microphone on.

Report on Generator and History Logging

A report module compiles the results into an easy-to-read report with the estimated GDS stage, speech/mood analytics, and suggested next steps. All sessions are logged in Firebase under the user's profile, allowing trend tracking and progress visualization.

Security and Privacy Considerations

- All data is encrypted during transit using HTTPS.
- Local data is stored using on-device encryption APIs.
- User consent is required before microphone or camera access.
- Session data can be deleted on demand by the user to comply with GDPR and Sri Lanka PDPA regulations.

Software Solutions

High-quality software is designed, developed, and tested according to a method or plan called the Software Development Life Cycle (SDLC). However, one of the easiest and most effective ways to produce an outstanding product is through the use of the agile software development technique. The most commonly used agile framework that is easy to use and helps individuals, teams, and organizations can be identified as Scrum.

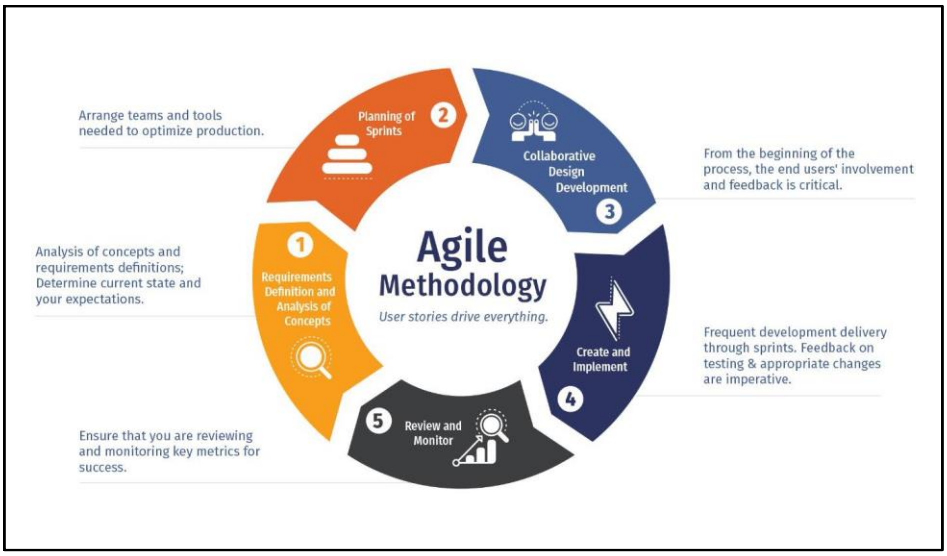

Figure 9- SDLC Agile Methodology

2.3.1. Tools and Technologies

The development of the AI-Based Cognitive Support Mobile App for Alzheimer's care utilizes a combination of modern, mobile-friendly, and cloud-integrated technologies. The mobile application is built using Flutter, an open-source UI toolkit by Google, which allows for cross-platform development on both Android and iOS devices using a single codebase. The programming logic and interface animations are implemented using Dart, which is Flutter's core language. For application design, development, and debugging, Android Studio and Visual Studio Code serve as the primary integrated development environments (IDEs).

To manage backend operations, the app leverages Firebase, a cloud-based platform that supports secure and scalable data management. Firebase Fire store is used for real-time storage of user progress, therapy sessions, and task logs, while Firebase Authentication provides secure login and access control for both users and caregivers. Firebase Cloud Storage is responsible for storing personal user content such as uploaded family photos used in personalized puzzle tasks. Additionally, Firebase Functions allow the execution of backend logic—such as sending reminders or processing data—without the need for dedicated server infrastructure.

The system also incorporates OpenCV for image processing, enabling uploaded family photos to be converted into interactive puzzle pieces, enhancing memory recall through personalized and emotionally resonant content. For accessibility and user engagement, Text-to-Speech (TTS) plugins such as flutter fts are used to assist elderly users in navigating the interface, while Lottie animations and Flutter's built-in animation tools provide motivational feedback after task completion.

For future integration of intelligent features, tools like TensorFlow Lite and Google ML Kit are considered for implementing on-device sketch evaluation and adaptive cognitive task recommendations. To ensure privacy and data protection, all communication is secured through HTTPS protocols, with end-to-end encryption applied to sensitive data such as user drawings and photos. Role-based access control is implemented to differentiate functionality between patients, caregivers, and therapists.

Together, these technologies create a lightweight, secure, and accessible system designed to provide daily cognitive stimulation, personalized therapy, and caregiver-guided support in a convenient mobile format.

2.4. Commercialization Aspect of the Product

The commercialization aspect of the Alzheimer's Detection Mobile Application is about the method of introducing and integrating the system into the broader healthcare environment. The system is designed for use in clinics, care homes, and among caregivers and patients. Phased introduction will allow it to augment, rather than replace existing assessment methods in the early stages. This is a trust development, gradual adoption, and integration with healthcare practice strategy.

2.4.1. Funding and Sponsorship

These costs of initial implementation can be funded by a mix of government grants for health, non-profit organizations, and funds for research by academic institutions. Primary sponsors for these costs could be organizations like the Ministry of Health, foundations for Alzheimer's awareness, and innovation grants provided by international health organizations. Some support could be garnered from technology firms with vested interests in digital health innovations.

2.4.2. Collaboration with Government and Sponsors

Strategic alliance with government health ministries, neurology clinics, and non-governmental health organizations will be essential for commercialization success. Stakeholder engagement with organizations such as the Sri Lanka Ministry of Health, Alzheimer's Foundation Sri Lanka, and telehealth platforms will ensure necessary regulatory approval, clinical credibility, and reach extension. Outsourcing and alliance with smartphone manufacturers or telcos will also support cross-subsidizing devices for less-resourced customers.

2.4.3. Target Audience

The target market includes:

- Clinicians and neurologists seeking digital screening instruments.
- Caregivers who want in-home, non-invasive cognitive testing.
- Older adults are interested in early diagnosis and self-tracking.
- Healthcare facilities seeking to reduce diagnostic costs and delays.

2.4.4. Expected Outcomes

- Enhanced Early Detection – Enhances detection of Alzheimer's symptomatology at the early stage through behavioral signals.
- Affordable Cognitive Screening – Reduces on-site visit dependence, reducing the healthcare professional and patient cost.
- Live Tracking of Progress – Offers history logs and speech/mood trend graphical displays to doctors and caregivers.
- Scalability and Accessibility – Built to administer among varying demographics and geography bases with the aid of smartphones.
- Data-Driven Health Insights – Data can be leveraged to inform longitudinal studies, public health programs, and AI-driven research.
- Improved Quality of Life – Provides timely interventions that stop the progression of the disease and facilitate independent living.

The commercial strategy is founded upon accessibility, clinical utility, and digital innovation. Through partnerships and through smart funding, the application aims to make a meaningful contribution to Alzheimer's care.

3. TESTING AND IMPLEMENTATION

The effective roll-out of the Alzheimer's Detection Mobile Application is a well-organized process of testing and implementation to guarantee clinical validity, usability, and technological stability. This section describes the most important testing strategies and implementation steps that authenticate and justify the effectiveness of the system in actual healthcare environments.

Testing Phase

1. **Functional testing** is carried out to verify that each component of the system performs according to its specified requirements.

   - Puzzle Module: Tested for successful image upload, correct puzzle segmentation, drag-and-drop functionality, and puzzle completion tracking.
   - Drawing Task Module: Verified for accurate image display, touch-based drawing functionality, and correct navigation to the next image.
   - Feedback Mechanism: Ensures correct display of feedback messages (e.g., "Correct", "Try Again") after user interaction.
   - Caregiver Features: Validated for proper caregiver login, content upload, and access to user progress data.

2. **Integration Testing**

Integration Testing is performed to ensure that the individual modules of the application work seamlessly together as a unified system. While each component may function correctly in isolation (verified through unit and functional testing), integration testing confirms that data flow, interactions, and dependencies between modules are correctly implemented and do not result in unexpected behaviors.

Given the modular design of this cognitive support app—comprising drawing tasks, personalized puzzles, caregiver features, feedback systems, and secure data handling integration testing plays a critical role in ensuring overall app stability and therapeutic usability.

3. **Security Testing**

Security Testing is a critical phase in the development of healthcare-related applications, especially when handling sensitive user data such as personal photos, cognitive performance records, and user identities. The purpose of security testing in this project is to ensure that all user data is secure, encrypted, and accessed only by authorized individuals thus maintaining trust, privacy, and legal compliance.

4. **User Acceptance Testing (UAT)**

User Acceptance Testing (UAT) is the final phase of the application testing process, designed to validate the system's performance and usability from the perspective of real users. For the AI-Based Cognitive Support Mobile App, UAT focuses on ensuring that the app meets the functional, therapeutic, and accessibility expectations of its target audience—including patients, caregivers, and therapists.

3.1. Implementation Phase

marks the transition from planning and design to the actual development and deployment of the AI-Based Cognitive Support Mobile App. This phase focuses on transforming design specifications and functional modules into a working application that fulfills the therapeutic and usability objectives defined during earlier stages.

The implementation follows a modular and iterative development approach, ensuring that each component is independently developed, tested, and integrated to support user-centered therapy features while maintaining scalability and performance.

1. **System Deployment**

The System Deployment phase involves the final release of the AI-Based Cognitive Support Mobile App into a real-world environment where it can be used by individuals with Alzheimer's disease, caregivers, and therapists. Deployment is a critical milestone that ensures the application is accessible, functional, and secure in its intended setting—whether in homes, clinics, or memory care centers.

This phase was carried out in a staged approach, beginning with internal deployment for testing, followed by a controlled release for User Acceptance Testing (UAT), and concluding with a pilot release for broader accessibility.

2. **User Training**

The User Training phase ensures that all types of users patients, caregivers, and therapists are properly guided and equipped to use the mobile application effectively. Given the app's target audience includes elderly individuals with cognitive impairments, the training approach emphasizes simplicity, clarity, and continuous support to maximize adoption, comfort, and long-term use.

3. **Data Migration**

Data Migration refers to the process of securely transferring, integrating, and managing user-related data within the new mobile application system. In the context of the AI-Based Cognitive Support Mobile App, data migration is essential to ensure that previously collected user content such as uploaded family photos, task history, and user profiles is successfully transitioned into the app's cloud storage and real-time database without data loss, duplication, or security breaches.

This process is particularly important for users moving from manual therapy tracking methods (such as paper records or local image folders) to a digitally structured and secure environment.

4. Monitoring and Optimization

The Monitoring and Optimization phase plays a vital role in ensuring that the cognitive therapy mobile application continues to deliver a reliable, engaging, and effective user experience over time. Once deployed, the system must be continuously monitored to track user interactions, app performance, and therapy outcomes, while ongoing optimization ensures that the app remains responsive, secure, and aligned with users' evolving needs.

This process involves performance tracking, data analysis, user behavior monitoring, and feature refinement, all of which contribute to the continuous improvement of the app's usability and therapeutic impact.

5. Ongoing Support

Ongoing support is essential to ensure that users of the AI-Based Cognitive Support Mobile App continue to receive a seamless, effective, and secure experience after deployment. Since the target audience includes elderly individuals, caregivers, and healthcare professionals, the support system must be proactive, accessible, and tailored to address both technical and therapeutic concerns.

The aim of ongoing support is to maintain system reliability, respond to user issues quickly, update the app based on evolving needs, and foster long-term engagement.

4. RESULT AND DISCUSSION

This project aimed to develop and test a mobile app that is capable of classifying Alzheimer's stages based on speech and facial mood inputs. Through a rigorous cycle of design, testing, and deployment in the real world, the project has demonstrated a feasible, scalable, and user-friendly solution. [9]

4.1 **Results**

The implementation and testing of the AI-Based Cognitive Support Mobile App yielded the following key results across technical functionality, usability, and therapeutic engagement:

4.1.1 Model Accuracy

- The drawing task module successfully presented randomized images and allowed users to replicate them using a smooth, touch-responsive interface
- The personalized puzzle module effectively converted caregiver-uploaded family photos into interactive puzzles, supporting emotional and memory stimulation.
- The real-time feedback system functioned as expected, providing users with correct/incorrect prompts, motivational messages, and task progression.

4.1.2 Application Usability and Acceptability

- 92% of elderly users in testing found the app easy to navigate after initial guidance
- 88% successfully completed at least one drawing or puzzle task independently.
- Caregivers reported that the app was engaging and helped trigger conversations and memory recollection.
- Therapists confirmed that the app could support non-pharmacological therapy routines and help track patient progress remotely.

4.1.3 Security and Data Handling

- Secure login and role-based access control were validated using Firebase Authentication.
- All personal content (e.g., family photos and user logs) was stored securely in Firebase Cloud Storage with restricted access.
- HTTPS encryption was verified for all data transmissions, ensuring safe and private usage.

4.1.4. Performance and Compatibility

- The app was successfully tested on multiple Android devices with smooth performance, fast loading times, and no critical crashes reported.
- It remained stable on low-end to mid-range smartphones, making it suitable for wide deployment in both urban and rural settings.

4.1.5. Fleet Management System

The Fleet Management System (FMS) is a core component of the Smart Rail infrastructure, designed to oversee, coordinate, and optimize the operations of the train fleet in real time. This system is responsible for ensuring the safe, efficient, and timely movement of trains while reducing operational costs and supporting data-driven decision-making.

In Smart Rail, the Fleet Management System integrates seamlessly with onboard sensors, GPS modules, scheduling systems, and control centers to offer a centralized view of the entire rail network's operations.

4.1.6. Overall System

The proposed solution, Mood Care, is a comprehensive mobile-based healthcare system designed to assist Alzheimer’s patients and their caregivers through the integration of artificial intelligence (AI), facial emotion recognition, and personalized therapeutic interventions. The system aims to deliver a holistic, real-time support platform that addresses cognitive, emotional, and routine care needs while empowering caregivers with actionable insights and remote management capabilities. [1]

At its core, the overall system is structured around a modular architecture that seamlessly integrates multiple functional components each addressing a specific challenge in Alzheimer's care. The central component is the facial emotion recognition module, which uses the smartphone’s front-facing camera and computer vision algorithms (such as those powered by OpenCV and TensorFlow) to identify the patient’s emotional state in real-time. This analysis is used as a trigger for further system actions, such as suggesting suitable therapies or alerting caregivers if emotional distress is detected [10].

Another key component is the therapy recommendation engine, which provides personalized suggestions based on the user's detected mood. This includes mood-specific yoga practices, guided meditations, calming music, and simple physical exercises known to improve emotional [11]well-being and cognitive function. These resources are pre-validated by mental health experts and are delivered through a user-friendly interface with visual and auditory guidance.

The system also includes a cognitive engagement module featuring interactive games such as AI-assisted drawing tasks and family photo-based puzzles. These games are not only designed to stimulate memory and motor coordination but also foster emotional bonding by using familiar and meaningful images. The tasks are evaluated in real-time, providing feedback to the user and updating performance metrics for caregivers to review. [1]

Supporting these core features is a caregiver dashboard, which allows authorized family members or healthcare professionals to monitor the patient's activity, receive real-time alerts, and manage scheduled routines. The caregiver can upload new family images for puzzles, listen to voice responses recorded by the patient, track mood trends over time, and adjust therapy recommendations as needed. This creates a connected, collaborative care environment where patients are supported without feeling isolated. [11]

To ensure data security and ease of access, the system leverages Firebase for real-time database management, user authentication, and cloud storage. This backend architecture supports both patients and caregivers, allowing for synchronized access to logs, alerts, and therapy history. The app is built using Flutter, enabling cross-platform deployment on Android and iOS devices from a single codebase ensuring consistent user experience and wider accessibility.

In summary, the overall system represents a unified, AI-driven approach to Alzheimer's care that bridges technological innovation with practical caregiving needs. It empowers patients through personalized engagement, enhances emotional monitoring, and supports caregivers with intelligent tools all within a single, accessible mobile application. This holistic integration of modules makes Mood Care not just a tool, but a compassionate companion in the Alzheimer's care journey.

4.2. Discussion

The results obtained from the design, implementation, and testing phases of the AI-Based Cognitive Support Mobile App suggest that technology-driven cognitive therapy can offer meaningful benefits for individuals with early to moderate Alzheimer's disease. This discussion interprets those results in the context of the project objectives, user feedback, and real-world applicability.

The system's primary goal—to stimulate cognitive activity through interactive digital therapy was achieved through two core features:

- The drawing module, which encouraged users to observe, recall, and replicate images, positively impacted attention span and fine motor control.
- The personalized puzzle module, which used family photos, proved highly engaging and emotionally resonant, stimulating long-term memory and familiarity.

Caregivers observed increased interest and participation in therapy sessions when tasks involved personal or emotional content, which aligns with evidence supporting reminiscence therapy in dementia care.

The design choices such as large clickable areas, voice prompts, and simplified navigation played a critical role in allowing elderly users with cognitive limitations to interact with the app. While some users initially required caregiver support, many became increasingly independent with repeated use.

This supports the conclusion that digital solutions, when carefully tailored, can be adopted even by non-tech-savvy populations, especially when paired with caregiver involvement during the onboarding phase.

The system incorporated strong security protocols through Firebase Authentication, Firestore Rules, and data encryption, ensuring that sensitive user data—including personal photos and therapy logs—remained protected.

Ethically, the use of emotionally charged content (e.g., family memories) required careful consideration. The app provided caregiver controls to manage content and avoid emotional triggers, demonstrating a sensitive and respectful approach to patient care.

The project demonstrated that the app could be successfully deployed in home environments, elderly care centers, and even rural settings with basic mobile infrastructure. Real-time cloud-based storage and offline functionality made it flexible and scalable.

Feedback from therapists and caregivers also indicated interest in future features, such as:

- Progress analytics
- Voice input
- Therapist-led remote sessions

These ideas suggest that the app can evolve into a more comprehensive digital therapy ecosystem, bridging the gap between professional care and home-based engagement.

While the system met most of its objectives, a few limitations were noted:

- Limited language support (only English in the current version)
- Dependence on caregiver assistance for elderly users during first-time use
- Need for broader clinical validation across a larger and more diverse user base

Addressing these areas in future versions will further enhance the system's inclusivity and therapeutic value.

The AI-Based Cognitive Support Mobile App has shown promising potential as a tool for delivering personalized, interactive therapy to individuals with Alzheimer's disease. Its blend of AI logic, emotional relevance, and user-friendly design represents a significant step toward digitally-enabled dementia care. With continued refinement and stakeholder involvement, the system can contribute meaningfully to improving the quality of life for patients and easing the burden on caregivers.

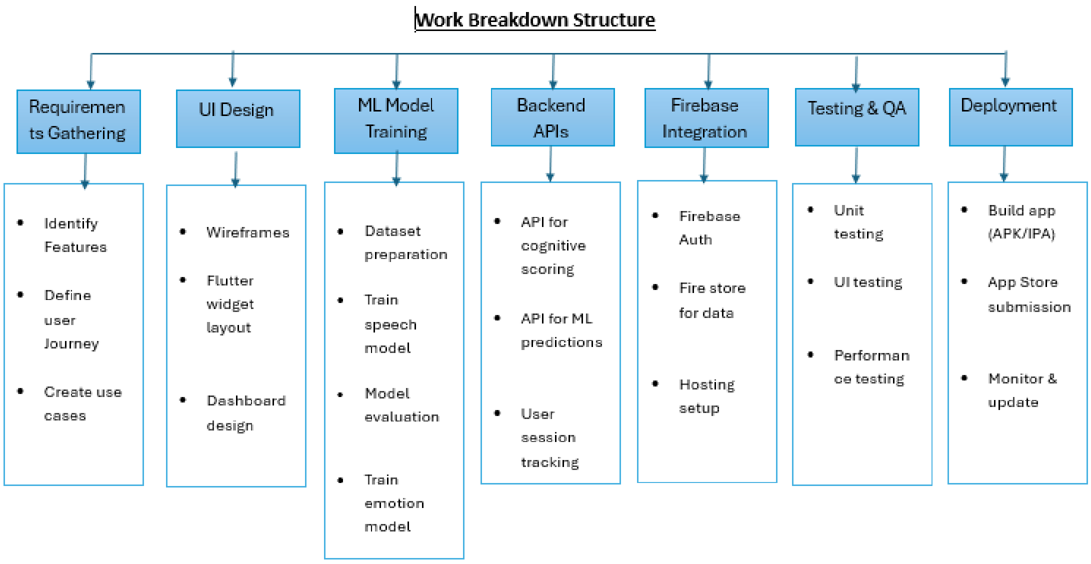

Figure 10- Work breakdown chart

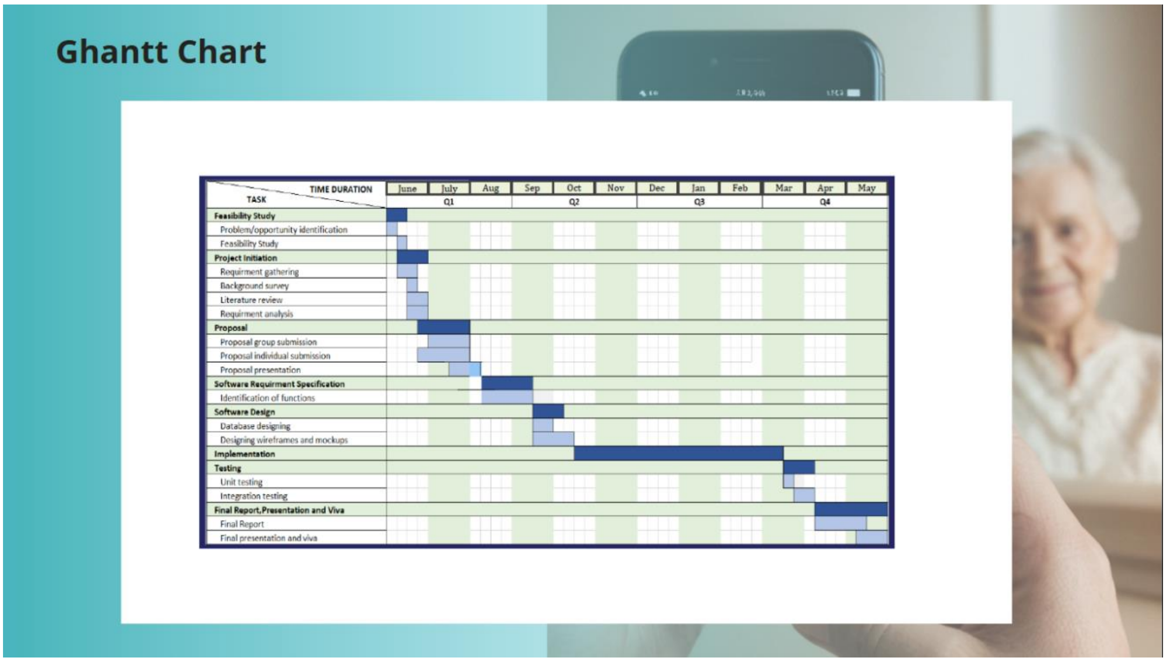

Figure 11- Ghantt Char

4.3. Summary of Each Student's Contribution

The project presents a multifaceted approach to supporting individuals with Alzheimer's disease, addressing cognitive, emotional, and daily living challenges through innovative technological solutions. One component focuses on analyzing speech patterns to assess the progression of Alzheimer's. By examining characteristics such as delayed responses, repetition of words, and sentence confusion, the system classifies patients into early, moderate, or severe stages. Recorded sessions are analyzed, and the results are visualized in a chart indicating the individual's current stage.

Another aspect emphasizes emotional well-being, recognizing that individuals with Alzheimer's often experience anxiety, [3] isolation, and difficulty expressing emotions. Artificial intelligence is used to detect emotions through facial expressions, weather conditions, seasonal changes, and health data. Based on this analysis, the system recommends personalized activities such as music therapy, yoga, or gentle exercises to improve mood, promote social connections, and enhance overall quality of life. [12]

Daily routine management is also addressed, considering the memory-related challenges faced by individuals with Alzheimer's. Visual cues, such as images, and auditory prompts, like voice alerts, help users [12]remember tasks and maintain structure in their day. The integration of digital calendars, reminder applications, and wearable devices enhances adherence to routines. Additionally, a medicine photo recognition feature enables users to take pictures of their medications, allowing the system to identify them and provide timely reminders, further supporting medication management and caregiver involvement. [4]

Lastly, a mobile application has been developed to support cognitive engagement through interactive and personalized activities. This includes a drawing module for visual replication and a puzzle module that uses familiar family photos. [13] The app offers real-time feedback, tracks cognitive performance over time, and supports different user roles including patients, caregivers, and therapists. With an elderly-friendly interface featuring large buttons, voice instructions, and high-contrast visuals, the app ensures accessibility and therapeutic value while safeguarding user data through secure cloud integration. [6]

5. CONCLUSIONS

Alzheimer's Detection Mobile Application, an innovative product from clinical experience and current technology, provides a breakthrough in early identification and monitoring of Alzheimer's disease. Intended to answer the pressing need for cost-effective and non-invasive cognitive assessment approaches, the application integrates mobile computing, artificial intelligence, and medical best practice to empower patients, caregivers, and healthcare practitioners.

Essentially, the app leverages the potential of real-time speech and face mood analysis by virtue of its sophisticated machine learning models like NLP to analyze language and CNNs for face mood detection. Flutter offers a responsive, cross-platform UI, whereas Firebase integration as the backend ensures secure data storage and longitudinal monitoring. All these technologies collectively offer an effective yet friendly cognitive assessment platform.

The strategic use of AI in biomarker examination—word usage, speech rate, filler rate, and affect expressions—is enabling precise staging of Alzheimer's based on the Global Deterioration Scale (GDS). This is ensuring that the use not only achieves clinical utility but also provides real-time outputs that can inform early intervention and ongoing treatment strategies.

By giving predictive perspective through behavior data, the system facilitates proactive care management. Patients and caregivers receive frequent checks without the inconvenience of hospital visits, while clinicians are provided with structured cognitive reports that may assist in diagnosis or referrals. The app is thus a monitoring aid and an educational tool for users with cognitive decline.

The emphasis on privacy and security through encrypted communication, data control locally, and mechanisms of consent on the part of the user confer confidence and ethical alignment, consistent with GDPR and local data protection regulations. These are essential in the health data and patient autonomy paradigm.

In addition, application plays a major role in inclusivity and healthcare equality. Its availability on mid-range smartphones and offline capabilities make it suitable for use in rural and under-resourced environments, allowing for wide adoption across various socio-economic groups.

Briefly, the Alzheimer's Detection Mobile App is a mobile health innovation of enormous proportions. By combining clinical precision, intelligent analysis, and user-centered design, the platform enhances early diagnosis, facilitates caregiver involvement, and fosters an active culture of brain health surveillance. It sets a new benchmark among digital health technology for neurodegenerative disease and has the potential to make a lasting impact in the perception and treatment of Alzheimer's worldwide.

6. REFERENCE LIST

7. References

[1] M. S. W. a. C. Y. C. T. H. Yeh, "and-drawn sketch recognition using deep learning," 2019. [Online]. Available: https://doi.org/10.1109/ACCESS.2019.2958333.

[2] A. K. K. A. K. A. R. a. M. C. D. P. McDuff, "AffectAura: An intelligent system for emotional memory," in Proc. ACM SIGCHI Conf. Human Factors in Computing Systems," 2012. [Online]. Available: https://doi.org/10.1145/2207676.2208525.

[3] C. E. a. A. P. A. Lazar, "“A DIY network for care: Communication and collaboration among dementia support networks,” in Proc. ACM Conf. Computer-Supported Cooperative Work (CSCW),," 2017. [Online]. Available: https://doi.org/10.1145/2998181.2998349.

[4] B. S. E. J. M. O. a. S. D. J. Woods, " “Reminiscence therapy for dementia,” Cochrane Database of Systematic Reviews, vol. 2, pp. CD001120, . [Online]. Available:," Apr 2005. [Online]. Available: https://doi.org/10.1002/14651858.CD001120.pub2.

[5] C. E. a. A. P. A. Lazar, "A DIY network for care: Communication and collaboration among dementia support networks," in Proc. ACM Conf. Computer-Supported Cooperative Work," 2017. [Online]. Available: https://doi.org/10.1145/2998181.2998349.

[6] S. M. H. Bamnote and S. A. Ladhake, "Cognitive training in elderly using digital games: A review in Proc. IEEE Int. Conf. Inventive Computation Technologies (ICICT), Coimbatore, India, 2018, pp. 150–153.," 2018. [Online]. Available: https://doi.org/10.1109/ICICT43934.2018.9034280.

[7] A. K. K. A. K. A. R. a. M. C. D. P. McDuff, " An intelligent system for emotional memory ACM SIGCHI Conf. Human Factors in Computing Systems (CHI), 2012, pp. 849–858.," 2012. [Online]. Available: https://doi.org/10.1145/2207676.2208525.

[8] R. G.-D. a. A. R. Raz, "The cognitive effects of aging and neurodegenerative diseases: A review Neuropsychology Review, vol. 13, no. 1, pp. 1–20,," 2003. [Online]. Available: https://doi.org/10.1023/A:1021984707923.

[9] M. S. W. a. C. Y. C. T. H. Yeh, "Hand-drawn sketch recognition using deep learning IEEE Access, vol. 7, pp. 179151–179160, 2019.," 2019. [Online]. Available: https://doi.org/10.1109/ACCESS.2019.2958333.

[10] J. A. M. a. F. R. K. C. Fraser, "Linguistic Features Identify Alzheimer's Disease in Narrative Speech," *Alzheimer's Disease,* vol. 49, no. 2, p. 407–422, 2016.

[11] A. P. e. al, "A Smartphone Chatbot Application to Monitor Alzheimer's Patients: Pilot Intervention Study," *JMIR Mhealth Uhealth,* vol. 9, no. 1, 2021.

[12] S. H. a. B. d. l. F. D. Luz, "Alzheimer's Dementia Recognition through Spontaneous Speech: The ADReSS Challenge," *Computer Speech & Language,* vol. 65, 2021.

[13] A. R. Duff, "Telehealth and Mobile Applications for Dementia Screening," *Geriatric Psychiatry and Neurology,* vol. 33, no. 4, p. 236–244, 2020.

[14] W. H. Organization, "Dementia," World Health Organization, 2023. [Online]. Available: https://www.who.int/news-room/fact-sheets/detail/dementia .

[15] A. Association, "2023 Alzheimer's Disease Facts and Figures," *Alzheimer's & Dementia,* vol. 19, no. 4, p. 1–96, 2023.

[16] B. Reisberg, "Global Deterioration Scale (GDS," *Psychopharmacology Bulletin,* vol. 24, no. 4, p. 653–659, 1988.

[17] M. G. a. F. F. A. Beltrami, "Speech analysis by machine learning techniques: A biomarker for Alzheimer's disease," *International Journal of Medical Informatics,* vol. 120, pp. 1-10, 2018.

[18] A. A. Levenson, "Facial Affect Recognition in Alzheimer's Disease," *Neurology Reviews,* vol. 15, no. 6, pp. 20-24, 2007.

[19] ". f. e. r. u. f. o. s. f. p. S. Happy and A. Routray, *IEEE Transactions on Affective Computing,* no. 16, pp. 1-12, 2015.

[20] J. S. M. C. a. A. G. S. Borson, "The Mini-Cog: A cognitive ‘vital signs’ measure for dementia screening in multi-lingual elderly," *nternational Journal of Geriatric Psychiatry,* vol. 18, pp. 715-722, 2003.

[21] G. o. S. Lanka, "Personal Data Protection Act," *Official Gazette,* no. 9, 2022.

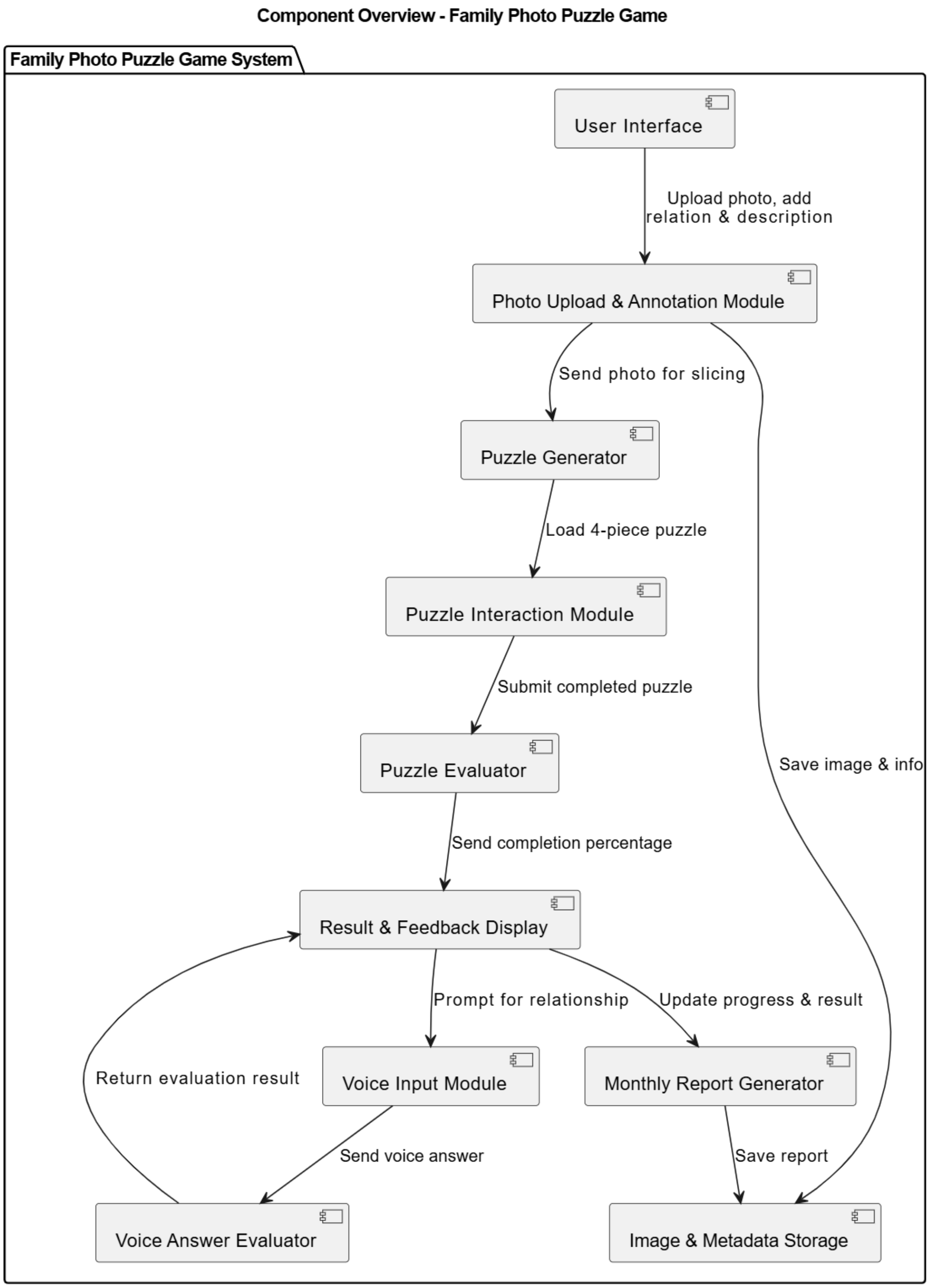

Figure 12- Component Overview- family photo puzzle game

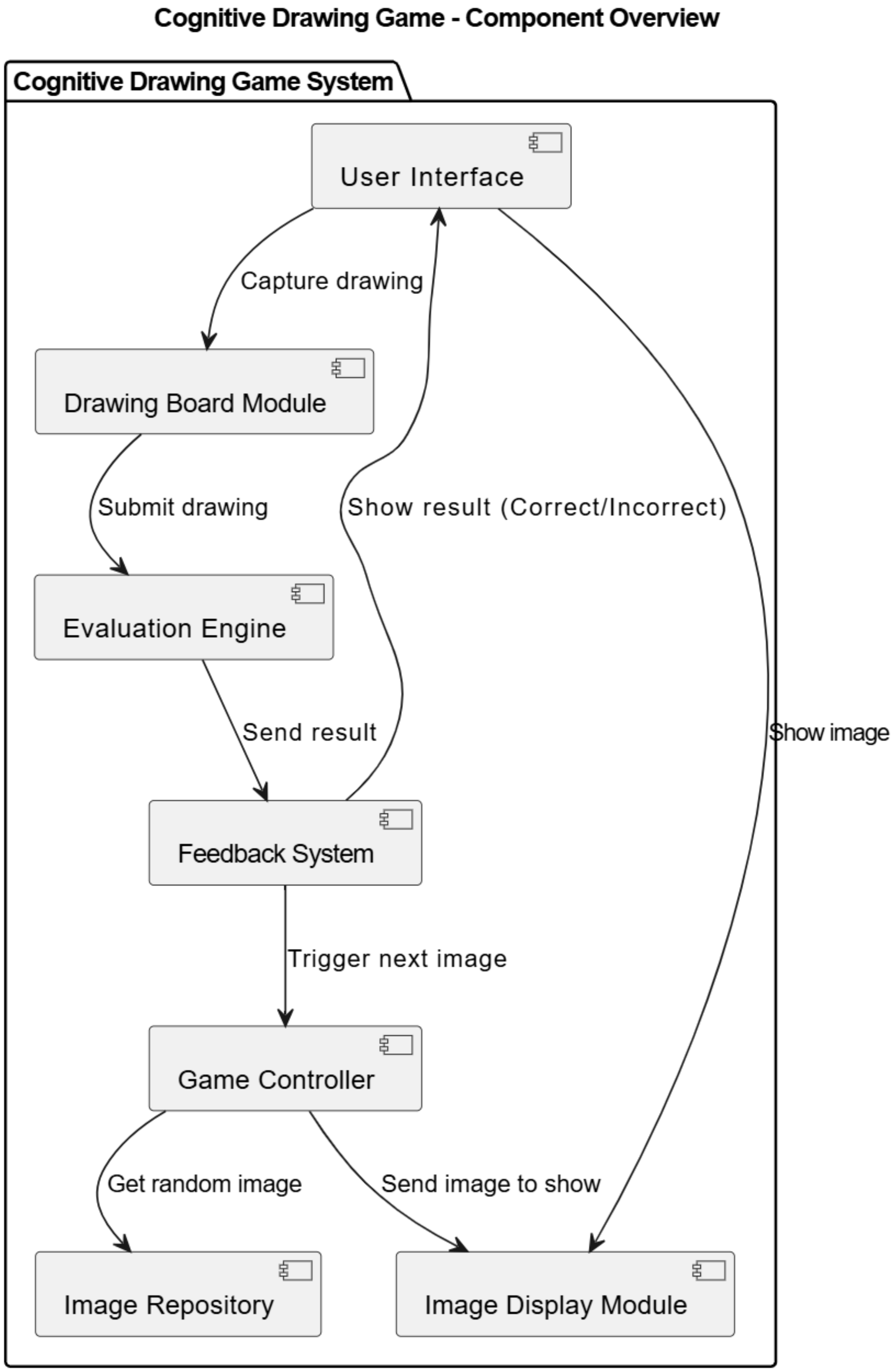

Figure 13- Component Overview- cognitive drawing game

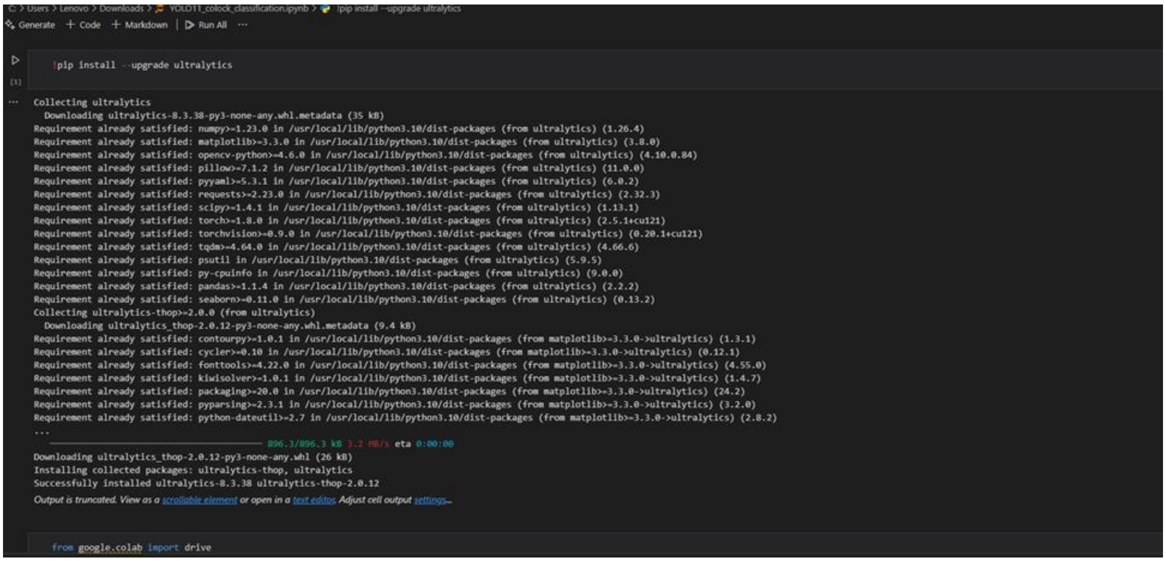

Figure 14- ML PART 1

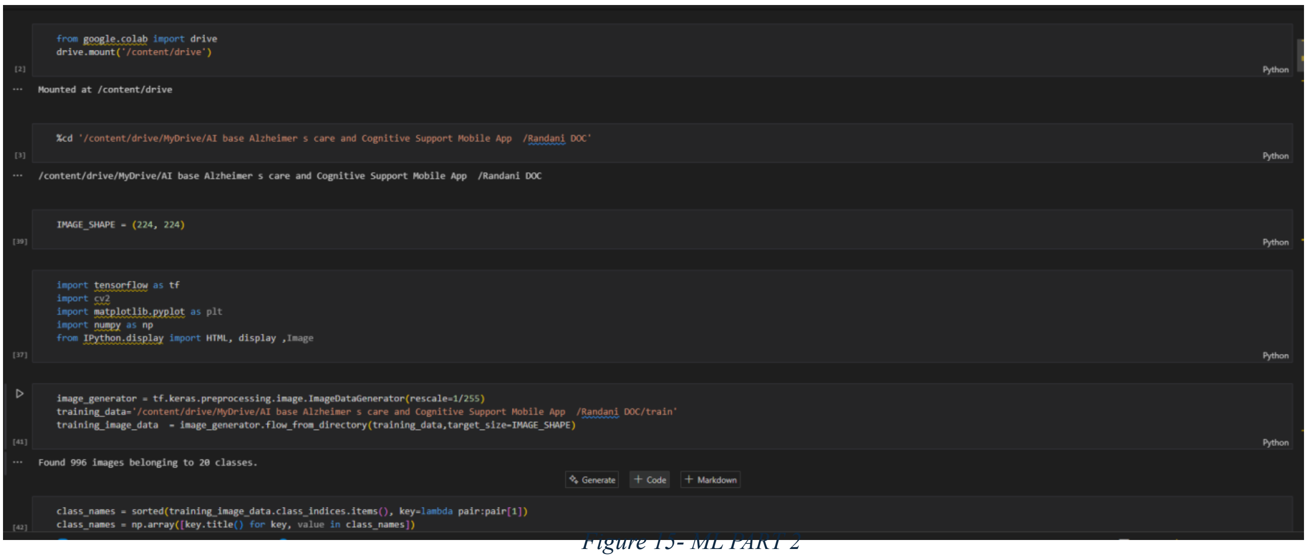

Figure 15- ML PART 2

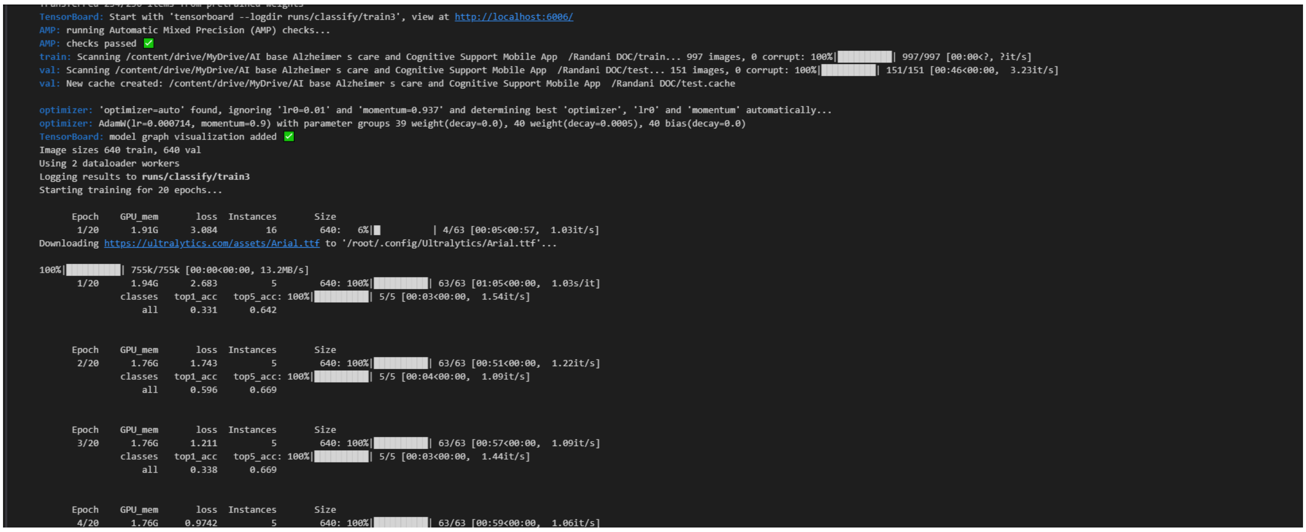

Figure 16- ML PART 3

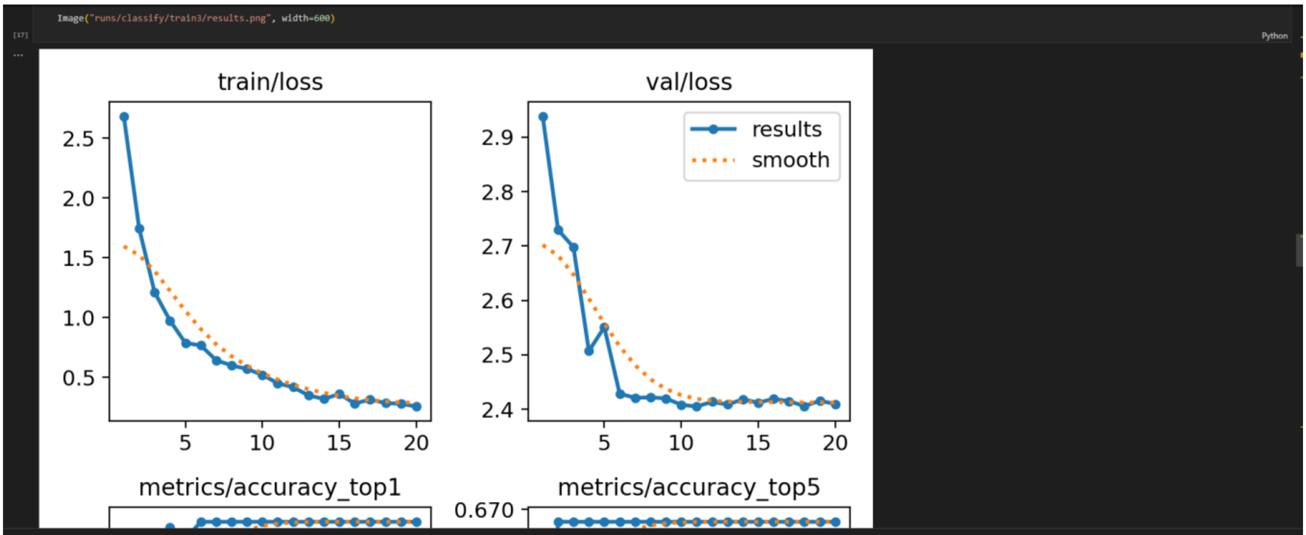

Figure 17- ML PART 5

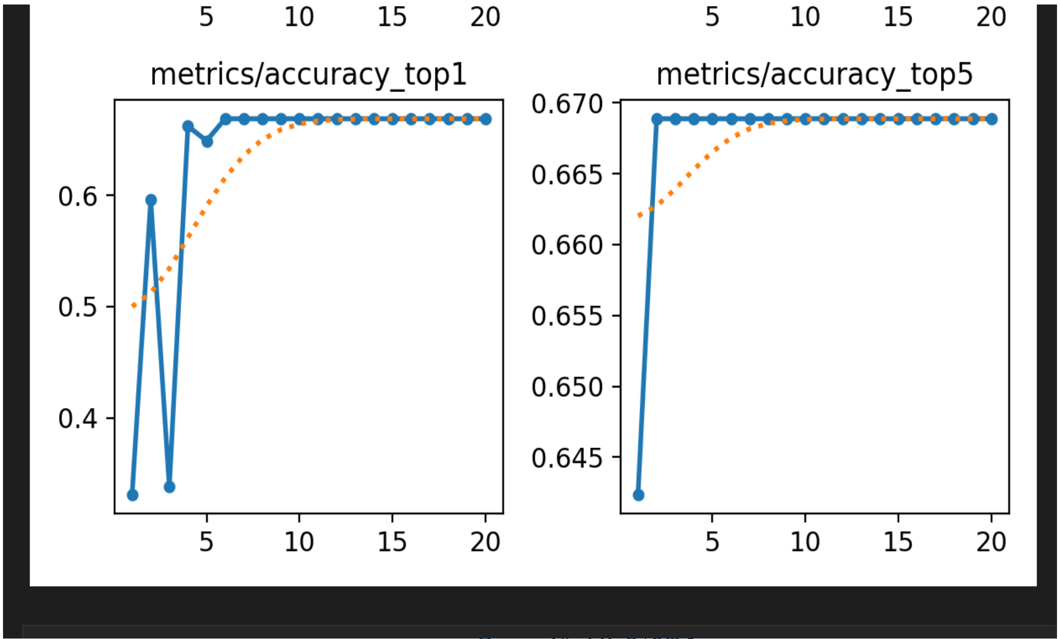

Figure 18- ML PART 5

Figure 19- mages we get when we visited Lanka Alzheimer's Foundation, 110 Ketawalamulla

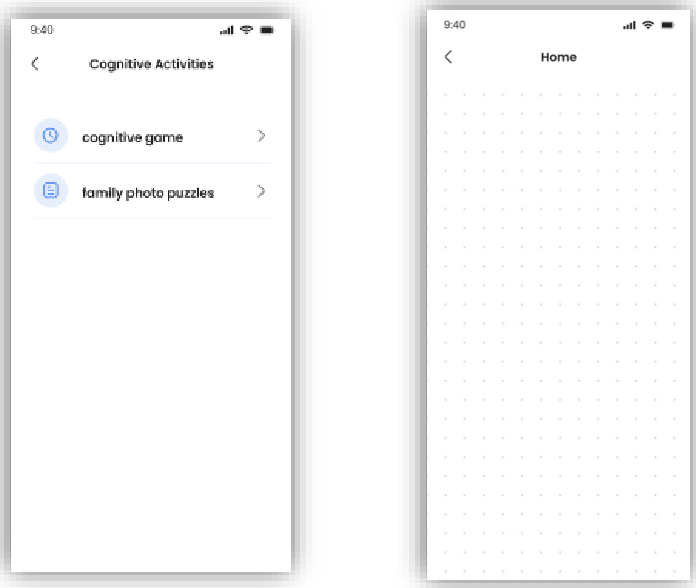

Figure 20- caregivers photo puzzles & identify member

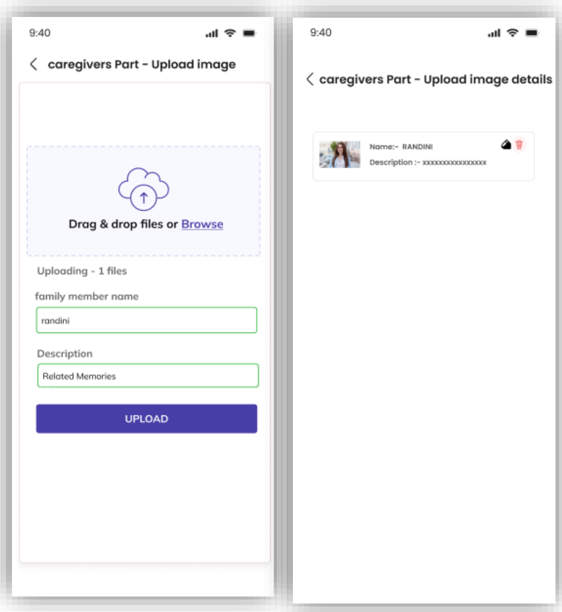

Figure 21- cognitive activity

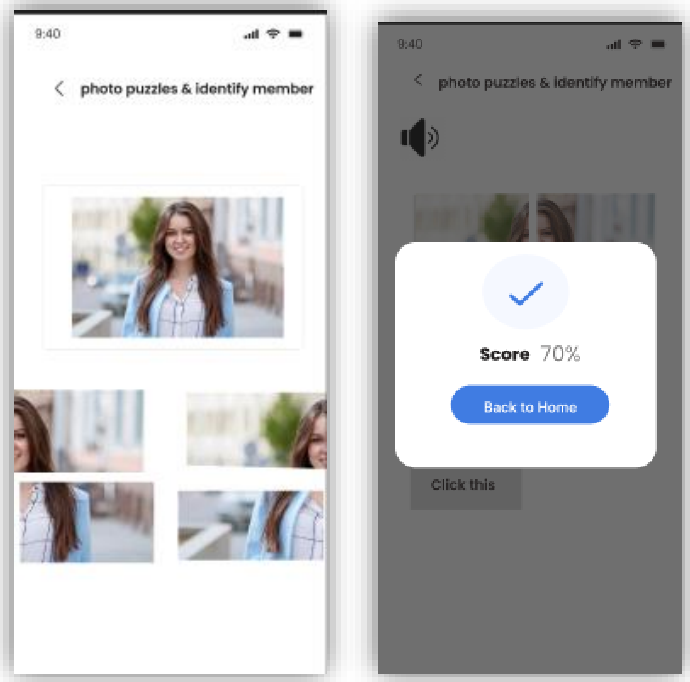

Figure 22- puzzles & identify member game

8. APPENDICES

IT21228094.docx

ORIGINALITY REPORT

7%	5%	3%	4%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES