AI base Alzheimer's care and Cognitive Support Mobile App

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Research Final Report

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Dissertation submitted in partial fulfilment of the requirements for the Bachelor of Science (Hons) in Information Technology

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DECLARATION

I declare that this is my own work, and this proposal 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.

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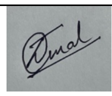
Imal Menuka Sandaruwan W. M.	IT21231100	

The above candidates are carrying out research for the undergraduate Dissertation under my supervision.

Signature of the Supervisor

(Ms. Uthpala Samarakoon) Date

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ABSTRACT

This research project focuses on the development of an advanced emotion recognition and therapeutic recommendation system for Alzheimer's patients. The system aims to improve patient well-being by accurately detecting emotional states and suggesting personalized interventions. Through a user-friendly interface, caregivers and healthcare professionals can input patients' facial expressions, which are analyzed using machine learning algorithms to identify moods such as happiness, sadness, and anger.

One of the core features of the system is the ability to track and categorize emotional states over time, providing caregivers with a comprehensive view of the patient's emotional well-being. The system allows users to input various therapeutic interventions, such as yoga, meditation, music, and exercise, which can be assigned to specific emotional states. A drag-and-drop functionality is integrated to easily assign these therapies based on real-time mood detection, followed by a confirmation step to ensure the correct interventions are selected.
Furthermore, the system includes a predictive functionality that forecasts the emotional states based on historical data and trends. This prediction feature provides caregivers with insights into the future emotional condition of the patient, enabling them to proactively adjust therapeutic strategies. The predictive analysis is accessible through a specialized icon, guiding users to a dedicated interface for forecasting mood changes and therapy needs.

By enhancing real-time emotional recognition and offering targeted therapeutic recommendations, the system empowers caregivers to provide personalized and timely interventions. It facilitates better decision-making, improves the patient's mental well-being, and optimizes the caregiving process, ultimately contributing to a more effective and compassionate approach to Alzheimer's care.

ACKNOWLEDGEMENT

First and foremost, I would like to express my heartfelt gratitude to **Mrs. Uthpala Samarakoon**, my supervisor, for her exceptional guidance, unwavering support, and insightful feedback throughout the course of this research. Her professional expertise and continuous encouragement were instrumental in shaping this project, especially in aligning the technical aspects with practical needs in Alzheimer’s care. I am deeply grateful for her commitment and the time she dedicated to mentoring me from concept development to implementation.

I am also sincerely thankful to my co-supervisor, **Ms. Poorna Panduwawala**, for her technical expertise and invaluable insights. Her attention to detail and critical thinking played a key role in refining the **facial mood recognition system** and enhancing the core functionalities related to **mental well-being suggestions** such as yoga, meditation, exercises, and music recommendations.

In addition, I wish to extend my appreciation to all the **lecturers, advisors, and industry professionals** who supported this research, especially the team at the **Alzheimer’s Foundation Sri Lanka**. Their field knowledge and medical expertise added immense value, particularly in validating the use of **non-pharmaceutical interventions** like mindfulness-based practices and social engagement tools to support Alzheimer's patients.

I also acknowledge with gratitude the contributions of **yoga instructors, meditation experts, fitness trainers, and mental health consultants**, whose professional advice guided the selection and customization of wellness practices tailored to patients’ emotional states.

Finally, I express my deepest thanks to my **friends and family** for their moral support, patience, and encouragement throughout this journey. Their belief in me helped bring this research to life.

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PSS	Perceived Stress Scale
RSE	Rosenberg Self-Esteem Scale
BSQ-34	Body Shape Questionnaire-34
ML	Machine Learning
AI	Artificial Intelligence
OCR	Optical Character Recognition
UAT	User Acceptance Testing
API	Application Programming Interface
UI	User Interface
UX	User Experience

1. INTRODUCTION

1.1. Background & Literature Survey

Alzheimer’s disease (AD) is a progressive neurodegenerative disorder that severely impacts cognitive function and memory. It is the most common cause of dementia, affecting millions of people worldwide, particularly the elderly population. The World Health Organization (WHO) reports that over 50 million people globally suffer from dementia, and this number is expected to increase as the population ages . Alzheimer's disease not only affects the individual but also places a significant burden on caregivers, families, and healthcare systems. It is characterized by the gradual loss of memory, reasoning, and other cognitive abilities, ultimately leading to a complete dependence on caregivers for daily tasks.

The cause of Alzheimer's disease remains largely unknown, although several factors contribute to its onset, including genetic, environmental, and lifestyle factors. Amyloid plaques and tau tangles in the brain are among the most well-known pathological features of the disease. These protein deposits disrupt communication between neurons, leading to their death and the subsequent cognitive decline that patients experience.

Currently, there is no cure for Alzheimer’s disease, and existing treatments mainly focus on alleviating symptoms or slowing the progression of the disease. Medications such as cholinesterase inhibitors and glutamate regulators aim to improve communication between neurons, but their effectiveness is limited. The need for early detection and personalized treatment plans has never been more crucial, and advancements in technology, particularly machine learning and artificial intelligence (AI), offer new possibilities for improving diagnosis and patient care.

In recent years, researchers have increasingly focused on using AI and machine learning models to detect Alzheimer's disease early. These approaches can analyze large datasets, such as medical imaging, genetic information, and patient history, to identify patterns and predict disease onset with greater accuracy. Studies have shown that AI can help identify Alzheimer’s patients based on brain scans, speech patterns, and behavioral data.

One of the most promising areas of research involves using facial emotion recognition to assess mood and cognitive decline in Alzheimer's patients. Studies have demonstrated that changes in facial expressions can be a valuable indicator of emotional and cognitive state, even before noticeable physical or verbal symptoms appear. This technology has the potential to provide early detection, offering an opportunity to intervene before the disease progresses too far. Moreover, by understanding the emotional and behavioral patterns of Alzheimer's patients, personalized care can be provided, helping to improve their quality of life.

In Sri Lanka, where the aging population is steadily increasing, Alzheimer's disease presents a significant public health challenge. The lack of specialized healthcare services for elderly patients, coupled with limited access to early diagnostic tools, makes it difficult to manage Alzheimer's effectively. However, the integration of AI and machine learning in mobile applications for mood and cognitive recognition presents a unique opportunity to address these challenges.

The purpose of this research is to develop an innovative mobile application, *Mood Care*, that utilizes machine learning models to analyze facial expressions and predict the mood of Alzheimer's patients. By integrating yoga, meditation, exercise, and music therapy suggestions, *Mood Care* aims to offer a holistic approach to supporting the mental well-being of Alzheimer's patients. This research will not only contribute to improving early detection methods but also provide personalized therapeutic interventions, filling a crucial gap in current Alzheimer's care practices. The app’s ability to recognize and respond to the emotional needs of the patients ensures that the treatment is tailored to the individual, offering a more effective and personalized approach to managing Alzheimer's disease.

1.2. Research Gap

As the world advances technologically, there has been an increasing integration of artificial intelligence (AI) and machine learning (ML) in various fields to improve efficiency and decision-making. In healthcare, particularly in the management and early detection of Alzheimer’s disease (AD), there has been significant progress. However, despite the advancements in diagnostic tools, the early detection and personalized care for Alzheimer’s patients remain substantial challenges. Existing diagnostic methods often rely on clinical assessments, cognitive tests, and medical imaging, which are time-consuming and can only detect the disease at later stages. This presents a significant gap in providing timely interventions that could potentially slow or halt disease progression.

Recent studies have explored using AI, particularly deep learning (DL) models, to detect Alzheimer's disease from brain scans and other medical data. For instance, convolutional neural networks (CNNs) have shown promise in classifying images of the brain and identifying patterns that are indicative of Alzheimer's before symptoms become pronounced. However, these studies primarily focus on detecting the disease at a later stage, when the damage to the brain is already significant. Additionally, while these methods provide valuable insights, they often require large datasets and high computational resources, making them less accessible and difficult to deploy in real-world, resource-constrained environments like those in Sri Lanka.

In contrast, the existing research does not sufficiently focus on the early detection of mood changes, which could be an earlier indicator of Alzheimer’s disease progression. The ability to detect mood variations (such as sadness, anger, or happiness) in patients with Alzheimer's disease, using accessible methods like facial expression recognition, could offer a new approach to early diagnosis and personalized care. While several studies have used facial emotion recognition in other contexts, applying this technology specifically to Alzheimer’s disease diagnosis is still in its infancy. Facial expression analysis, in conjunction with AI and machine learning, could provide a non-invasive and real-time method of assessing the emotional state of patients, helping caregivers and healthcare providers understand the patient’s needs more effectively.

Moreover, most of the current applications in Alzheimer’s care lack integration with personalized therapeutic interventions such as yoga, meditation, and exercise, which have been shown to be beneficial for patients' mental well-being. While music therapy is commonly prescribed, integrating more diverse therapeutic interventions based on real-time mood recognition and predictive modeling of disease progression remains underexplored. This gap presents an opportunity for enhancing the personalized care of Alzheimer's patients through a holistic approach that incorporates not only early detection but also continuous, adaptive therapeutic interventions.

In this context, *Mood Care*, an application leveraging machine learning models to detect facial expressions and recommend personalized therapies such as yoga, meditation, and exercise, can address these gaps. By using facial emotion recognition to predict a patient’s mood, the application can offer a real-time understanding of emotional changes that may correlate with cognitive decline. This provides a much-needed tool for healthcare providers to deliver timely interventions before more severe symptoms manifest. Furthermore, by incorporating personalized therapy suggestions, the app can enhance the mental well-being of Alzheimer's patients, improving their quality of life and offering more tailored care than current methods.

Application Reference	**Mood Detection (Facial)**	**Music Recommendation**	**Yoga & Meditation Guidance**	**Exercise Suggestions**	**Group Chat for Social Well-being**
Research A [12]	✗	✓	✗	✗	✗
Research B [13]	✗	✓	✗	✗	✗
Research C [14]	✗	✓	✗	✗	✗
Proposed System	✓	✓	✓	✓	✓

Table 1 Comparison with Previous Research

In summary, while AI and machine learning have been explored for Alzheimer's disease diagnosis, significant gaps remain in terms of early detection using non-invasive, easily accessible methods like facial expression analysis. Additionally, there is limited research on integrating personalized therapy suggestions in real-time care systems. The proposed *Mood Care* app aims to bridge these gaps by combining facial recognition for mood detection with personalized, non-pharmacological interventions, ultimately offering a more comprehensive approach to managing Alzheimer's disease.

Existing systems and feature comparison.

The current system used for Alzheimer's disease management primarily involves cognitive assessments, clinical evaluations, and medical imaging, which are time-consuming and typically diagnose the disease only in its later stages when significant cognitive decline has already occurred. In these systems, there is little to no integration of real-time monitoring or personalized intervention recommendations, which hinders early intervention and proactive care. Additionally, current diagnostic tools mainly focus on cognitive performance tests and imaging results, leaving a gap in understanding and responding to the emotional and psychological states of Alzheimer's patients.

The proposed *Mood Care* system, however, introduces a comprehensive solution by integrating facial expression recognition technology, machine learning models for mood detection, and personalized therapeutic interventions. By utilizing real-time facial emotion analysis, *Mood Care* can detect changes in the patient's mood (such as happiness, sadness, or anger), which may serve as early indicators of cognitive decline or changes in the emotional state of the patient. This system's predictive capability offers healthcare providers valuable insights into the emotional well-being of Alzheimer's patients, enabling more timely and personalized interventions, such as music, yoga, meditation, and exercise.

The key difference in the proposed system is its ability to predict the emotional state based on real-time facial expression recognition, which can then be used to suggest adaptive therapeutic interventions tailored to the patient's current mood. This predictive approach allows caregivers and healthcare providers to monitor mood fluctuations proactively and intervene earlier, potentially preventing further psychological distress or cognitive deterioration. The *Mood Care* system thus aims to provide personalized, non-pharmacological therapy recommendations based on individual patient needs, leading to more effective care and improving the overall well-being of Alzheimer's patients.

By combining mood recognition with therapy suggestions, the *Mood Care* system enhances the traditional approach to Alzheimer's care, making it more adaptable, real-time, and personalized. This contrasts with the traditional reliance on static cognitive tests and medical evaluations, offering a more holistic and dynamic solution for managing the emotional and cognitive aspects of Alzheimer’s disease.

2. RESEARCH PROBLEM

The research problem emerges from the limitations in existing systems for managing Alzheimer's patients. Currently, care for Alzheimer’s patients is largely reactive, with interventions based on periodic cognitive assessments and observable behavioral changes. This approach fails to address the emotional and psychological needs of patients, often leading to delayed intervention, especially in early stages. The existing systems also lack the capacity to provide real-time monitoring of emotional states, which is crucial for understanding the immediate mental and emotional well-being of patients.

Additionally, current Alzheimer's care systems are generally static, with no personalized therapeutic recommendations based on real-time mood detection. The absence of predictive tools that can forecast potential emotional and cognitive decline from early-stage data exacerbates the problem. As a result, caregivers and healthcare providers often miss early signs of distress or changes in the emotional state of the patient, which could be crucial for preventing further cognitive decline or behavioral issues.

This research aims to fill this gap by developing a system that not only detects the emotional state of Alzheimer’s patients through real-time facial recognition but also predicts potential changes in their emotional and cognitive conditions. The proposed system will incorporate machine learning models that analyze facial expressions to assess mood and recommend personalized interventions such as music, yoga, meditation, and exercise. This solution seeks to provide a dynamic, data-driven approach to managing Alzheimer's care, ensuring that interventions are timely, targeted, and tailored to the specific needs of the patient, thereby improving overall patient outcomes and quality of life.

3. OBJECTIVES

3.1. Main Objective

Alzheimer's disease is a progressive neurodegenerative disorder that impairs cognitive functions, including memory, thinking, and behavior. These impairments significantly impact both patients and caregivers, often leading to emotional distress and difficulty in providing effective care. The main objective of this research is to develop a system that uses facial emotion recognition technology to detect the emotional states of Alzheimer's patients in real-time. By integrating this system with personalized therapeutic interventions such as music, meditation, yoga, and exercise, the goal is to enhance the emotional well-being of patients.

Additionally, the system will predict future emotional states based on current and past data, enabling caregivers to provide timely, appropriate interventions and improve overall care strategies. This innovative approach will help in improving the quality of life for Alzheimer's patients and assist caregivers in managing the emotional and cognitive challenges associated with the disease.

3.2. Specific Objectives

3.2.1. Design a flexible emotional state monitoring platform that allows caregivers to customize, adjust, and modify therapeutic interventions.

One of the main challenges in Alzheimer's care is the inflexibility of current care systems, which often follow a standardized approach to treatment and therapy. However, emotional states in Alzheimer's patients can vary greatly throughout the day, and even within a specific day, depending on various factors such as time of day, environmental triggers, and overall health. Current systems often fail to address this fluctuation, making it difficult to provide personalized care that meets the unique needs of the patient at any given moment.

To address this, the first research sub-objective is to design a flexible emotional state monitoring platform. This platform will allow caregivers to dynamically assess and adjust therapeutic interventions (such as yoga, meditation, music therapy, or physical exercises) based on the patient's current emotional state. The ability to monitor and modify interventions in real time ensures that Alzheimer's patients receive the most appropriate care tailored to their current emotional needs.

Some of the major features of this platform are:

- **Real-time emotion detection** through facial expression analysis or other sensor inputs to monitor the patient's emotional state continuously.
- **Personalized intervention suggestions** based on the patient's detected emotions, such as recommending relaxation exercises, specific music, or light physical activity.
- **Flexible user interface** for caregivers to adjust interventions on the fly, ensuring the patient receives the appropriate therapy at the right time.
- **Integration with personalized care plans**, allowing caregivers to add, modify, and resequence different therapeutic interventions according to the patient's ongoing emotional and physical needs.

This flexibility will enable caregivers to adapt their approach to care dynamically, improving emotional well-being and enhancing the overall therapeutic effectiveness for Alzheimer's patients.

3.2.2. Create a user-friendly interface that allows easy addition, modification, and assignment of therapeutic interventions to individual emotional states.

An intuitive interface is crucial for the smooth operation of any complex system, especially in healthcare settings like Alzheimer's care, where caregivers must monitor multiple aspects of a patient's well-being and adjust interventions quickly based on changing conditions. Many existing Alzheimer's care systems are hindered by non-intuitive interfaces, making it difficult for caregivers to respond swiftly to the patient's fluctuating emotional states or apply the most appropriate therapies.

To address this, the second sub-research objective is to design an easy-to-use user interface (UI) that allows caregivers to easily add, modify, and assign therapeutic interventions based on the patient's emotional state. The goal is to ensure that caregivers can manage the entire care process efficiently without requiring extensive training or dealing with complex system interactions. This will empower them to provide real-time, personalized care to the patients.

Some of the key features of the user interface will include:

- **Interactive dashboards** that allow caregivers to input and track the patient's emotional state, with easily understandable visual representations, such as mood indicators and emotion graphs.
- **Drag-and-drop functionality** for assigning therapeutic interventions (e.g., music, yoga, meditation) to the patient's emotional state, enabling caregivers to quickly adjust care plans in response to changes in the patient's mood.
- **Validation prompts and tooltips** to guide caregivers through the process, ensuring that the correct interventions are applied for the given emotional state, and that all data is accurate and consistent.
- **Real-time monitoring** that displays the patient’s current emotional state and suggests suitable interventions based on the real-time data, enhancing decision-making efficiency for caregivers.

By prioritizing user experience, this interface will minimize human error, streamline the caregiving process, and provide caregivers with the necessary tools to optimize their interventions, ultimately improving the quality of care provided to Alzheimer's patients.

3.2.3. Develop a predictive analytics model that will forecast final-stage emotional state outcomes from initial assessments and real-time data.

A major limitation of current Alzheimer's care systems is their reactive nature. Many existing systems rely on caregivers' observations or historical data, making adjustments only after a change in the patient's emotional state has already occurred. This reactive approach can lead to inefficiencies and delays in addressing the patient's needs. Predictive analytics has the potential to revolutionize Alzheimer's care by enabling caregivers to anticipate changes in the patient's emotional state and proactively adjust interventions.

The third sub-objective of the research is to design a predictive analytics model that will forecast the patient's emotional state at later stages based on early assessments and real-time data. Using machine learning algorithms, the system will learn from past emotional state patterns and utilize them to predict future emotional outcomes in real time. This predictive model will empower caregivers to make informed decisions, adjust interventions proactively, and reduce the likelihood of the patient experiencing emotional distress.

Some of the key highlights of this predictive analytics model will include:

- **Machine learning algorithms** that analyze historical data, such as past emotional states, interventions, and patient reactions, to predict future emotional states (e.g., happy, sad, angry).
- **Predictive modules integrated into the system's user interface**, providing caregivers with real-time information about likely emotional outcomes based on current data, enabling them to adjust interventions before issues arise.
- **Personalized care recommendations** based on predicted emotional states, allowing caregivers to deliver timely and tailored interventions, such as music, yoga, or meditation, based on the patient's needs.

Through predictive analytics, the system will enable caregivers to make proactive decisions, enhance emotional well-being, optimize intervention strategies, and ensure that Alzheimer's patients receive the most appropriate care at the right time.

3.2.4. Implement an intuitive user interface that enables easy addition, modification, and assignment of mood and therapy interventions to specific emotional states.

A user-friendly interface is essential for the effective operation of any system, particularly in Alzheimer’s care, where caregivers must monitor emotional states and respond quickly to changes in the patient's well-being. Currently, many caregiving systems for Alzheimer’s patients are limited by cumbersome, non-intuitive interfaces that make it difficult for caregivers to quickly modify therapy interventions or track emotional states.

To address this, the fourth sub-objective of the research focuses on developing an intuitive user interface (UI) that allows caregivers to easily add, modify, and assign emotional state interventions (such as music, meditation, yoga, and exercise) to specific emotional states. The goal is to ensure that caregivers can manage the entire therapeutic process efficiently without the need for extensive training or complex interactions with the system.

Key features of the user interface will include:

- **Interactive dashboards** that allow caregivers to input emotional state readings (e.g., happy, sad, angry) and assign appropriate therapies, with clearly defined categories for each type of intervention. This ensures accuracy and consistency in tracking emotional well-being.
- **Drag-and-drop functionality** to assign therapy interventions to specific emotional states, providing a simple and efficient method for customizing care plans based on real-time emotional assessments.
- **Validation prompts and tooltips** that guide caregivers through the process, helping them avoid errors by ensuring that the emotional state interventions are accurately and consistently applied.
- **Real-time emotional state monitoring capabilities** that display the patient's current emotional state and show suggested therapy interventions, allowing caregivers to track progress and adjust interventions as necessary.

By prioritizing user experience, the proposed interface will reduce operational inefficiencies, minimize human error, and enable caregivers to manage the therapeutic process effectively, ensuring that Alzheimer's patients receive timely, personalized interventions to support their emotional well-being.

4. METHODOLOGY

The proposed system is designed to offer a dynamic and flexible interface to manage personalized interventions for Alzheimer's patients based on their emotional states. The methodology involves several stages, starting with the ability for caregivers to assess and log emotional states, then provide personalized therapy interventions through an interactive interface. This system ensures caregivers can adapt interventions according to real-time needs and make decisions to improve the patient's well-being. The overall system follows a multi-tier architecture, ensuring ease of integration, scalability, and flexibility.

4.1. Requirement Gathering and Analysis

The first phase in the system development life cycle was a thorough requirement gathering and analysis phase. This phase was essential to understand the needs of caregivers, healthcare professionals, and the specific requirements related to managing the emotional states and well-being of Alzheimer's patients.

Some key activities involved in this phase were:

- **Stakeholder Interviews:** Conducted with caregivers, healthcare professionals, Alzheimer's specialists, and family members to understand the specific challenges they face in managing emotional states and offering therapy. This helped identify expectations, challenges, and workflows in providing emotional care.
- **Patient Interaction Observations:** Observations were conducted in Alzheimer's care settings to understand the emotional fluctuations patients experience and how caregivers currently manage these changes. This offered insights into the real-time challenges and gaps in the current methods of providing emotional support.
- **Documentation Review:** Relevant medical records, treatment plans, and existing guidelines on therapeutic interventions for Alzheimer's patients were reviewed. This helped identify patterns and standard practices for emotional care, highlighting deviations from ideal treatment or gaps in the current systems.

- **Pain Point Identification:** Some of the main issues documented during this phase included a lack of personalized care plans tailored to the emotional state of the patient, difficulty in tracking changes in emotional states over time, the absence of real-time intervention suggestions, and a lack of integration between emotional assessments and therapy interventions.

4.1.1. Functional Requirements

Functional requirements specify what the system should do and how it will operate. These requirements detail the essential functionalities that allow the system to interact with users and meet their needs effectively. Defining these requirements is crucial for the system's design and success.

- **Emotional State Detection and Classification:** The system should be able to accurately detect and classify the emotional states (happy, sad, angry, etc.) of Alzheimer's patients through facial recognition or other appropriate methods.

- **Personalized Therapy Recommendations:** Based on the detected emotional state, the system will provide personalized therapy suggestions, including music, yoga, exercise, or meditation, tailored to the patient's needs.

- **Real-Time Feedback and Adjustments:** The system should allow caregivers to track emotional changes in real-time and adjust therapy recommendations accordingly. This includes real-time adjustments based on new emotional data.

- **Tracking and History:** The system should store historical emotional data, therapy interventions, and patient responses. This data will help caregivers understand patterns over time and improve care plans.

- **User-Friendly Interface for Caregivers:** The system must provide a simple, intuitive interface that allows caregivers to quickly input data, receive therapy suggestions, and adjust treatments with minimal effort.

4.1.2. Non-Functional Requirements

Non-functional requirements define the qualities and attributes of the system that enhance user experience, security, and performance. These are critical in ensuring the system operates smoothly, efficiently, and securely.

- **Security:** The system must protect sensitive patient data, including emotional states, therapy history, and personal information. It should implement robust security measures such as encryption, secure authentication, and user role management to ensure data privacy and compliance with healthcare regulations.

- **Reliability:** The system should be reliable, functioning as expected without errors. It must be resilient to failures, offering fail-safes and backup systems to ensure continued operation even in case of hardware or software issues. Ensuring consistent functionality is vital to avoid disruptions in patient care.

- **Performance:** The system should perform efficiently, processing emotional state detection and therapy suggestions in real-time without excessive latency. It should use resources optimally to ensure fast response times, enabling caregivers to act quickly. High performance is essential, especially in real-time applications where delays can affect the quality of care.

- **Usability:** The system should be easy for caregivers to use, requiring minimal training. The interface should be intuitive and user-friendly, allowing quick access to emotional data, therapy suggestions, and patient history. Caregivers should feel comfortable using the system daily without frustration.

- **Scalability:** The system should be scalable to accommodate the growing needs of a large number of patients and caregivers. As more patients are added to the system, it should be able to handle an increasing amount of data without compromising performance.

- **Maintainability:** The system should be designed in a way that makes it easy to update and maintain. It should allow for quick troubleshooting and regular updates, ensuring that new features can be added, and any issues can be resolved swiftly.

4.2. Feasibility Study

4.2.1. Technical feasibility

Technical feasibility examines whether the proposed system can be developed using the available technology and whether the required expertise exists to implement it successfully. In the context of this Alzheimer's mood detection and therapy suggestion system, modern machine learning algorithms, computer vision techniques, and web/mobile technologies will be used. The system will integrate facial recognition or speech-based emotional detection with machine learning models trained on data to classify emotions.

The backend of the system will be developed using **Java Spring Boot**, which offers a reliable and scalable framework suitable for developing complex, modular systems. For the frontend, **React** with **TypeScript** will be employed for dynamic and responsive user interfaces. The system will store data in **MongoDB**, a NoSQL database known for its flexibility and scalability, making it ideal for storing patient records, therapy logs, and real-time emotional data. The use of these technologies is highly suitable due to their reliability, extensive community support, and ability to scale, making the project technically feasible.

4.2.2. Economic feasibility

Economic feasibility assesses the financial cost of the project and evaluates whether the investment is worthwhile. In this project, costs will primarily include the development and operational expenses such as server hosting for the web application, cloud services for machine learning model training, and third-party APIs for facial or voice recognition. Additionally, licensing for any specialized software or tools (e.g., machine learning frameworks, libraries) may contribute to the cost.

The cost will also include the infrastructure needed for maintaining real-time data storage and processing for patients' emotional data, as well as any ongoing costs for system maintenance and updates. Given the potential improvements in the well-being of Alzheimer's patients and the value it could add to healthcare practices, the expected benefits of the system, such as improved patient engagement, care, and quality of life, will likely outweigh the costs, making the project economically feasible.

4.2.3. Schedule feasibility

Schedule feasibility refers to the ability to complete the project within the specified timeframe. The estimated time for completion of the Alzheimer’s mood detection and therapy suggestion system is approximately **6 to 12 months**, which includes phases for development, testing, and deployment.

The development timeline will be broken down into phases, such as:

- **Requirement Analysis and Design** (1-2 months): Gathering data and designing the architecture of the system.
- **Backend Development and Frontend Development** (2-3 months): Developing the system’s core functionalities, including emotion detection, data processing, and real-time interaction features.
- **Integration and Testing** (1-2 months): Integrating the machine learning models and performing rigorous testing to ensure accuracy and reliability.
- **Deployment and User Training** (1 month): Deploying the system for live use and providing training to caregivers and healthcare professionals.

While challenges such as unforeseen technical issues or delays in obtaining necessary data may arise, the project timeline appears achievable given the planned resources and tools. By maintaining flexibility in adjusting certain milestones, the project is expected to meet the target schedule and be ready for deployment within the promised timeframe.

4.3. System Design

4.3.1. High-level overall system architecture diagram

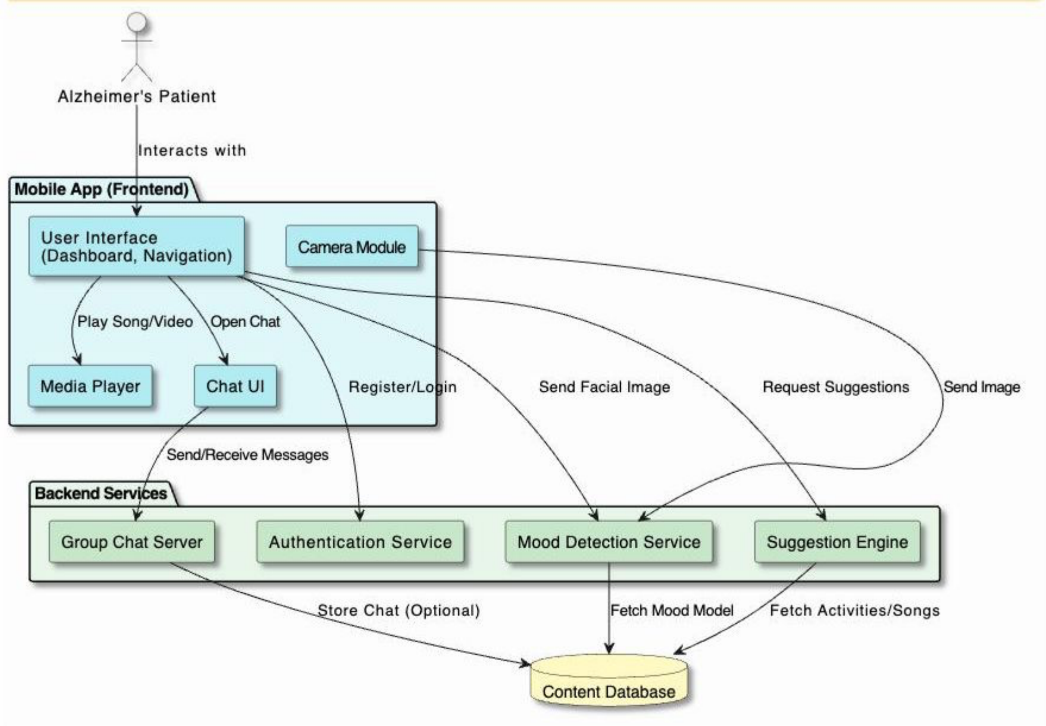

Figure 1 System architecture design

The system architecture of the Alzheimer's mood detection and therapy suggestion system follows a modular structure designed to optimize emotional analysis and therapeutic intervention through machine learning and user interaction. The architecture diagram below (Figure 2) illustrates the overall flow of the system, which includes multiple interconnected modules to ensure seamless data processing, prediction, and therapy suggestions.

At the core of the system is the **Emotion Detection Module**, which collects and processes real-time data from patients, using facial recognition or voice analysis to detect emotional states such as happy, sad, or angry. This data is then forwarded to the **Prediction and Therapy Module**, which uses trained machine learning models to analyze the emotional state of the patient and predict the most suitable therapeutic intervention, such as meditation, yoga, or music. The **Therapy Suggestions Module** provides tailored suggestions for each patient, considering their emotional state and personal preferences. These suggestions can include personalized playlists, yoga routines, or guided meditation sessions.

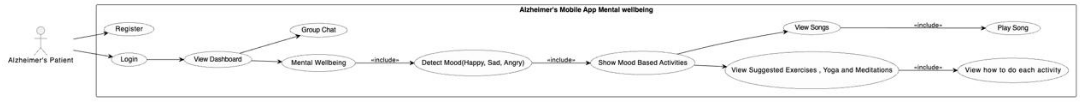

Figure 2 System diagram for flow customization

The system is structured using a multi-modular architecture, ensuring that each component operates independently while maintaining effective communication. This modularity guarantees scalability and maintainability as the system evolves. The primary modules of the system include:

1. **Emotion Detection Module**: Uses facial recognition or speech analysis to classify the patient's mood into predefined categories such as happy, sad, or angry.
2. **Prediction and Therapy Module**: Implements machine learning algorithms to predict appropriate therapeutic interventions based on the detected emotional state.
3. **Therapy Suggestions Module**: Generates personalized recommendations for yoga, meditation, exercise, or music therapy tailored to the patient's emotional and health status.
4. **Database Management Module**: Stores emotional analysis data, patient history, therapy recommendations, and other relevant information to support the system's predictive capabilities.
5. **User Interface Module**: Provides a seamless interaction experience for caregivers and healthcare providers to monitor the patient's emotional state, review predictions, and suggest appropriate therapies.

The **Emotion Detection Module** uses real-time data collection methods, such as video feeds or voice recordings, to assess the patient's emotional state. This data is processed using pre-trained machine learning models for emotion classification. Once the emotion is detected, the **Prediction and Therapy Module** evaluates historical patient data and determines the most appropriate therapeutic response. The system will also integrate feedback loops, ensuring that the suggested therapies are continually refined based on real-time patient responses and interactions.

The **User Interface Module** is designed with a focus on ease of use, ensuring that caregivers and healthcare providers can monitor patient moods and suggest therapies with minimal effort. Features such as interactive dashboards, real-time notifications, and seamless navigation make it easy for caregivers to manage patient well-being effectively.

The **Database Management Module** ensures that all patient data, including emotional states, therapy suggestions, and historical trends, is stored securely and efficiently, facilitating quick access and analysis. The relational database schema includes:

- **Patient Data**: Stores emotional state history, therapy interactions, and feedback.
- **Therapy Suggestions**: Records details of personalized therapy recommendations and their effectiveness.
- **Prediction Results**: Stores predictions from the machine learning models, allowing for analysis of therapy success over time.

Design Diagrams for the Component

Use Case Diagram

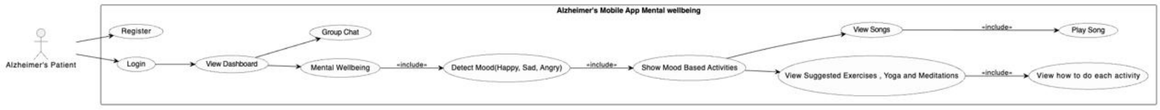

Figure 3 Use Case Diagram

Sequence Diagram

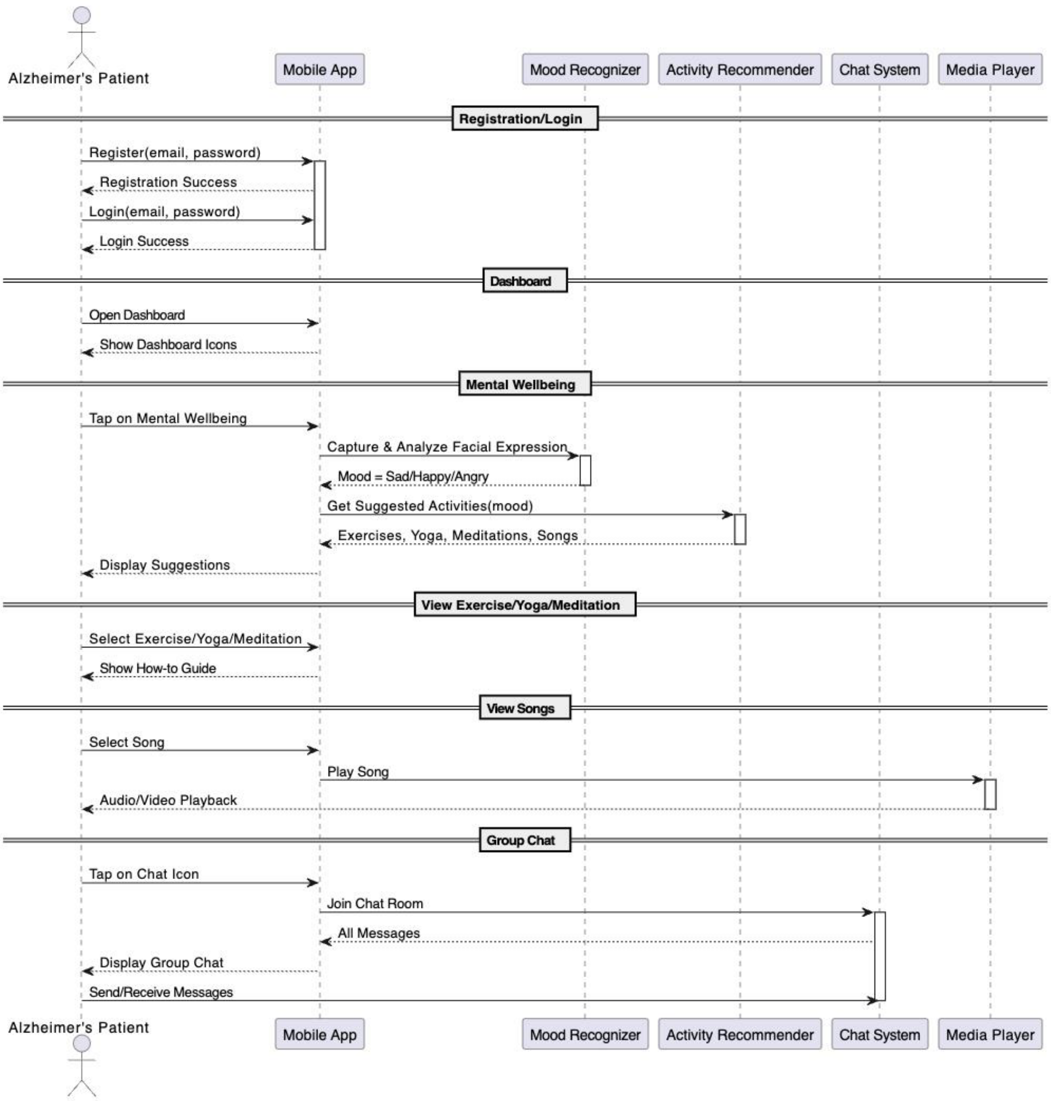

Figure 4 Sequence Diagram

Flow Chart

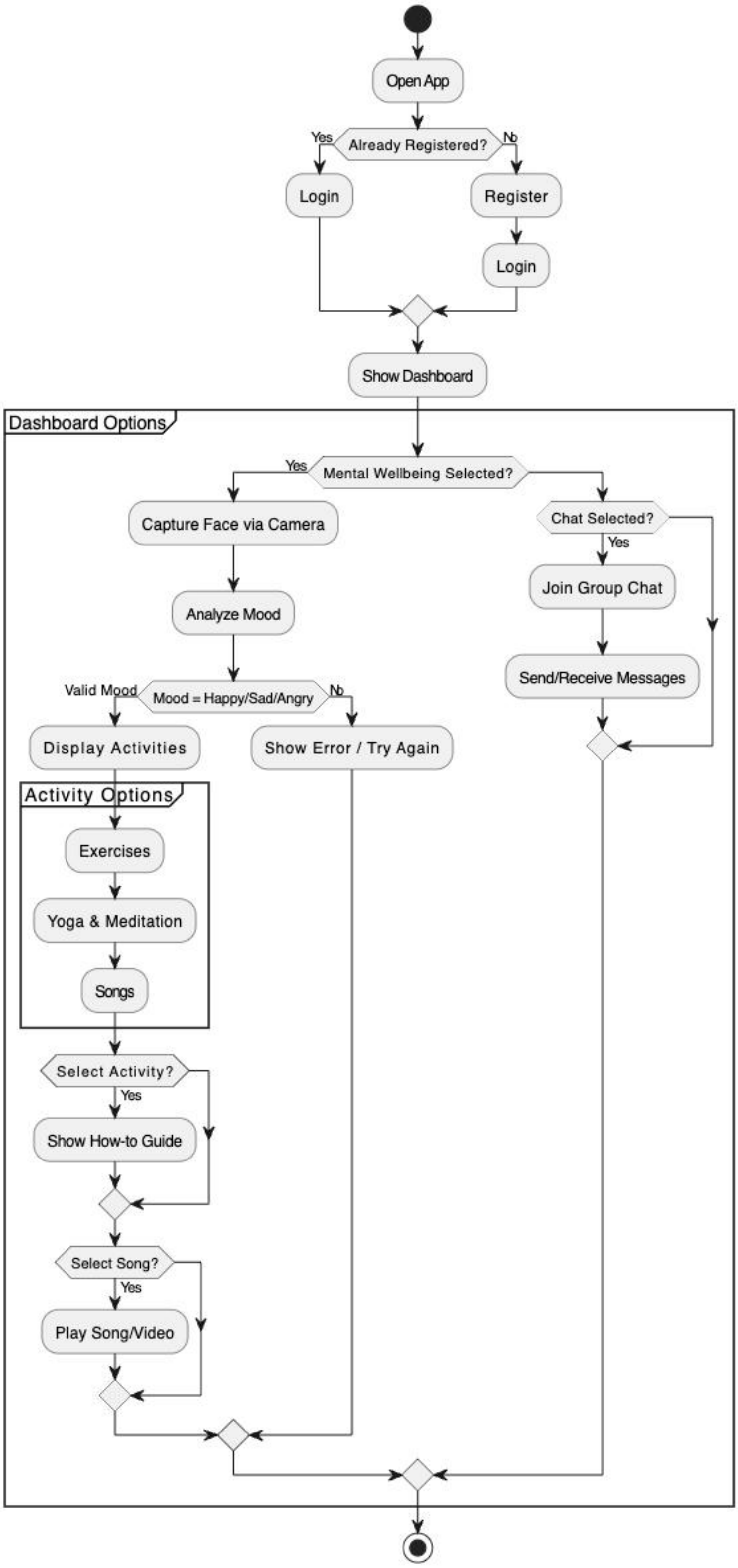

Figure 5 Flow Chart

4.4. Understanding the Key Pillars

4.4.1. Integration of the backend and the Flask server

The integration between the backend and the Flask server is a critical component of the Alzheimer's mood detection and therapy suggestion system. This integration ensures that the system can efficiently process data and provide real-time suggestions by combining the capabilities of both frameworks. The backend, built using a robust framework such as **Spring Boot** or **Node.js**, handles the primary functionalities, including user authentication, data storage, and overall system management. Meanwhile, the Flask server is dedicated to running the machine learning models responsible for analyzing the emotional state of the patient and providing personalized therapy suggestions.

In this system architecture, the **backend** serves as the core of the application, managing user requests, storing data (e.g., patient information, mood history, therapy suggestions), and handling business logic. The **Flask server**, on the other hand, is used for its strength in serving machine learning models via APIs. This lightweight server hosts the models responsible for emotion detection and therapy suggestion prediction. These models can include machine learning algorithms for mood classification (e.g., using facial recognition or speech analysis) and predictive analytics for suggesting personalized therapies based on detected moods.

To facilitate smooth interaction between these two components, **REST APIs** are employed. The backend communicates with the Flask server through HTTP requests, sending real-time input data (such as mood indicators) and receiving the necessary predictions and recommendations. This architecture offers flexibility, allowing each component to be developed, updated, and scaled independently. The backend can easily handle multiple users and manage the core logic of the system, while the Flask server can be optimized specifically for running the predictive models without interfering with the backend's operations.

4.4.2. Time series analysis for water quality prediction

In the context of Alzheimer's disease, **time series analysis** is an essential tool for predicting emotional states and improving the system's ability to offer personalized therapy suggestions. Just as water quality is monitored over time, mood detection relies on analyzing emotional data collected at regular intervals, often throughout the day. This analysis helps track changes in a patient's mood over time, which is crucial for accurate predictions and timely interventions.

Time series analysis in this system would involve collecting mood-related data at regular intervals (e.g., through facial recognition, speech patterns, or other emotional indicators). By organizing this data chronologically, the system can identify trends, patterns, and fluctuations in a patient's emotional state over time. This approach makes it possible to predict future emotional states and adjust therapy suggestions based on the detected trends.

4.5. Methodology

4.5.1. Definition of system scope and identification of data sources

For the emotional detection and therapy recommendation system aimed at Alzheimer's patients, the **system scope** and **data sources** are defined to ensure that the models used for mood prediction are accurate and reliable. In this case, data sources are crucial as they provide the foundational information required to train and evaluate the machine learning models for detecting emotional states and generating appropriate interventions.

System Scope: The system will focus on **detecting and analyzing emotional states** such as happiness, sadness, and anger in Alzheimer's patients, based on their facial expressions, speech patterns, and other emotional cues. This system will then generate **personalized therapy suggestions** such as music, meditation, yoga, or exercises that are tailored to the patient's emotional state. The scope of the system will also include

continuous monitoring to detect mood shifts over time and provide proactive interventions.

4.5.2. Data collection and preparation

Accurate and trustworthy predictions in the emotional state prediction system for Alzheimer's patients are largely dependent on the collection and preparation of data. In this stage, a variety of datasets, such as facial expression data, speech patterns, caregiver mood logs, and environmental factors, are systematically gathered, cleaned, and organized. The primary sources of this data include the video recordings from patients, speech recordings, mood logs from caregivers, and environmental data collected from the smart home system.

4.5.2.1. Data preparation for the final stage prediction Module

The dataset for the emotional state prediction model was compiled from various sources over a period of two years (2023–2025). Data was collected from video feeds, speech recordings, and daily logs maintained by caregivers. The video analysis system tracks facial expressions like smiles, frowns, and eyebrow movements, while speech pattern analysis captures tone, pitch, and cadence. Caregiver logs provide mood data based on emotional states, and environmental factors such as time of day and interactions are also logged.

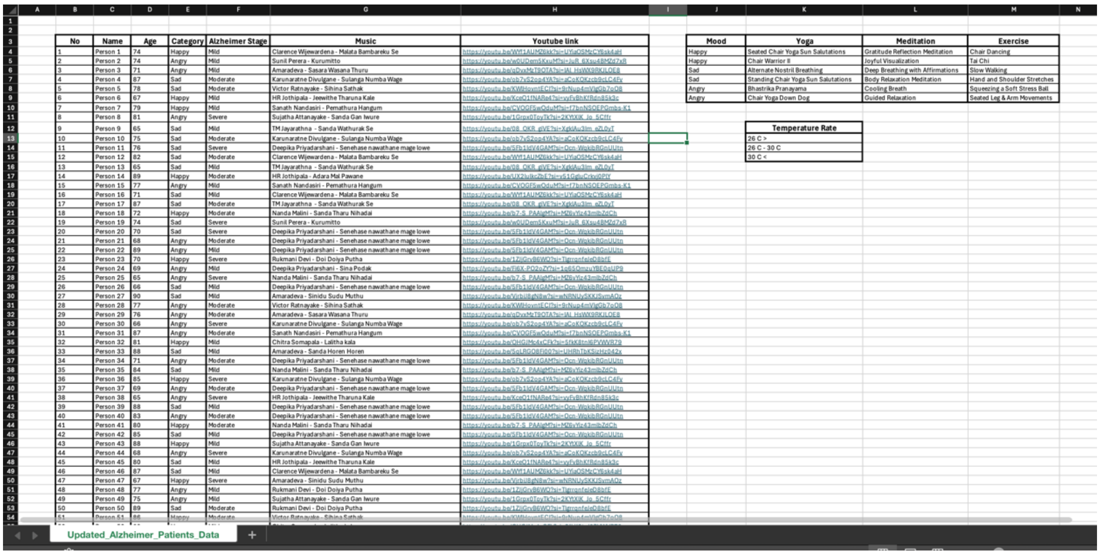

Figure 6 Snapshot of the pre-processed dataset

The dataset, which includes essential characteristics recorded at regular intervals, is shown in Figure 3. Among these parameters are:

- **Facial expression data**: Smile intensity, frown count, eyebrow movements
- **Speech patterns**: Tone, pitch, cadence, speech rate
- **Caregiver mood logs**: Emotional states such as happy, sad, frustrated
- **Environmental data**: Time of day, social interactions, ambient noise levels

While the caregiver logs offer subjective insights into the emotional state of patients, the facial expression and speech data provide more objective, quantifiable measures. The next stage was to prepare the data for training the emotional state prediction model after collecting the dataset. To ensure that the predictions would be accurate and reliable, several data quality issues were identified during this phase.

One of the initial challenges encountered was the inconsistency in the timestamps of facial expression and speech recordings. Many entries were recorded at different intervals, making it difficult to align the data accurately for model training.

	09:40A.M	Person 94	84	Happy	Severe	HR Jothipala - Jeewithe Tharuna Kale	https://youtu.be/KceQ1fNARe4?si=vyFvBhKfRdn85k3c
	11:00A.M	Person 95	73	Sad	Mild	Chitra Somapala - Lalitha kala	https://youtu.be/QHGJMc4xCFk?si=5fkK8tnl6PVWVR79
2021.05/.02	12:00A.M.	Person 96	65	Angry	Severe	Nanda Malini - Sanda Tharu Nihadai	https://youtu.be/b7-S_PAAlgM?si=oaQCJZp-W28BFeOL
	11:58A.M	Person 97	75	Angry	Severe	Sunil Perera - Kurumitto	https://youtu.be/w0UDem5KxuM?si=JuR_6Xsu4BMZd7xR
	08:40A.M	Person 98	90	Angry	Severe	Chitra Somapala - Lalitha kala	https://youtu.be/QHGJMc4xCFk?si=5fkK8tnl6PVWVR79

Figure 7 Example of wrong datetime entries in the dataset

Additionally, there were gaps in the speech data, with several missing speech segments, which impacted the prediction accuracy. The caregiver mood logs also had missing or inconsistent entries for certain days, leading to incomplete data points. To address these issues, several steps were undertaken to refine and prepare the dataset for model training. These included standardizing the timestamps, filling in missing mood data using imputation techniques, cleaning the speech data by removing irrelevant noise, and performing feature scaling to ensure that the model would process the data effectively. Additionally, environmental data was integrated into the dataset to provide a more comprehensive view of factors influencing emotional states. This ensured that the dataset was complete and well-suited for training the prediction model.

4.5.3. Model building and training.

Linear Regression Model Architecture:

For predicting the emotional states of Alzheimer's patients, a Linear Regression model is used as one of the primary predictive techniques. This statistical model is particularly effective in capturing the relationship between input features (such as facial expressions, speech patterns, and environmental data) and output labels (such as emotional states like happy, sad, or frustrated). Since emotional states often exhibit linear relationships with these features, the Linear Regression model serves as an ideal choice for this problem.

The model is trained to predict the emotional state of Alzheimer's patients based on initial inputs gathered from facial expressions, speech features, and environmental conditions, allowing for continuous, real-time mood tracking.

The Linear Regression model structure and deployment is as follows:

- **Input Features:** The model accepts input features like smile intensity, pitch, tone, cadence, and environmental factors such as time of day, and ambient noise levels.

- **Target Outputs:** The target variables are the emotional states (happy, sad, frustrated, etc.), represented as categorical values that are converted into numerical data for regression.

- **Data Preprocessing:** Missing or null values in the dataset are handled using forward-filling techniques. Temporal data, such as timestamps, are normalized for coherence. Input features are standardized using the Standard Scaler to ensure all data is on the same scale and to improve model performance.

Training Procedure:

For model construction, historical patient emotional state data from video and speech recordings were collected. Data from various sensors, such as those detecting facial expressions and analyzing speech patterns, were paired with emotional state labels from caregivers. The dataset was cleaned and pre-processed to ensure consistency. Standardization was applied to the features using Standard Scaler to normalize input values to have a mean of zero and a standard deviation of one.

The data was then split into training and test datasets to objectively assess the model's performance. The model was evaluated on the training set, and its prediction capabilities were tested using the test data. Though the initial model's R^2 value was moderate, it serves as a good baseline for the system, providing reasonably accurate predictions of patient emotional states.

After the model was trained and validated, it was serialized and stored for deployment. A prediction routine was designed to take raw input features from ongoing data collection (such as real-time facial expressions and speech inputs) and provide real-time predictions of emotional states. These predictions are valuable for making timely decisions, allowing caregivers and medical personnel to intervene before a negative emotional state escalates, thereby improving patient care.

The next steps involve refining the model using more advanced techniques, such as deep learning, and incorporating more diverse data sources to increase the accuracy of emotional state predictions.

4.6. Implementation

The presented research utilizes smartphone technology to develop an intelligent mobile application that supports **Alzheimer's patients' mental well-being** through mood recognition and personalized activity recommendations. This system enhances emotional regulation by detecting facial moods—**happy, sad, or angry**—and recommending appropriate **songs, yoga poses, exercises, and meditation practices** to uplift the patient's mood.

The application is developed using **Flutter** and **Dart**, allowing a user-friendly, cross-platform interface tailored for elderly users. It includes **group chat functionality**, enabling all logged-in users to interact with each other, promoting social bonding and reducing isolation—key factors in maintaining mental health.

A core feature of this module is the **facial expression recognition system**, which uses images captured from the user to identify emotional states. This is powered by **Python** and **Deep Learning** techniques, providing accurate mood detection and triggering relevant wellness content suggestions based on the recognized mood.

To further personalize the experience, the app integrates **Machine Learning** models that adapt over time, learning from user interactions and refining the wellness suggestions (e.g., which music calms them, which meditation they prefer when sad, etc.).

The system uses **Firebase** for real-time database management, authentication, and notifications—ensuring that patients receive instant suggestions and alerts. Additionally, **TensorFlow** is used for training AI models for facial expression analysis, making recognition both fast and accurate.

The app's development and testing were conducted using **Android Studio**, with **Git** used for version control and team collaboration throughout the project lifecycle.

For the implementation of the system the following technologies were used.

- **Flutter**
  For developing a cross-platform, responsive mobile application interface suitable for elderly users.
- **Dart**
  Programming language used with Flutter to build the app's frontend.
- **Python**
  Used for backend logic, facial mood recognition, and AI model integration.
- **TensorFlow**
  Applied to develop and train deep learning models for facial mood recognition.
- **Firebase**
  Enables real-time database functionality, user authentication, and instant notification services.
- **Machine Learning**
- **Personalizes mood-based suggestions by analyzing user behavior and preferences.**
- **Deep Learning**
  Provides accurate and advanced facial expression recognition capabilities.

- Android Studio
- The main IDE for building, debugging, and deploying the mobile application.
- Git

  Used for version control and seamless collaboration within the development team.

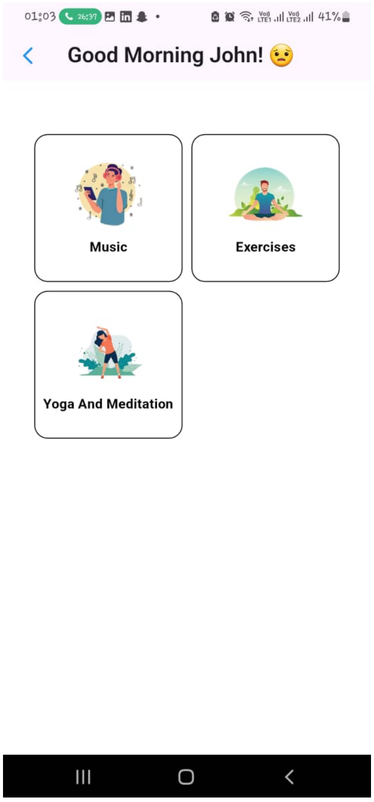

Figure 8 Activity Suggestion Page

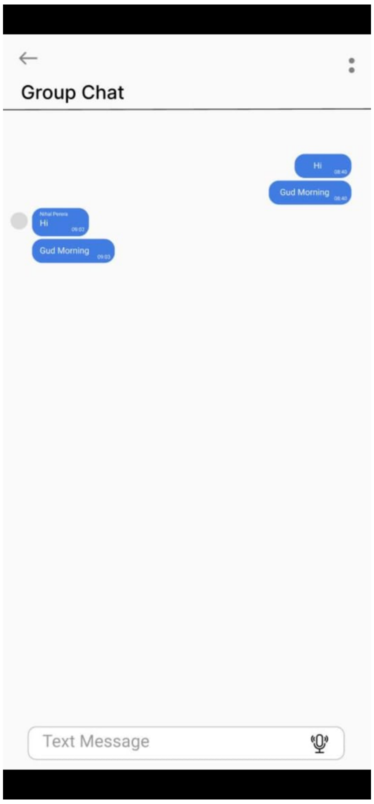

Figure 9 Group chat UI

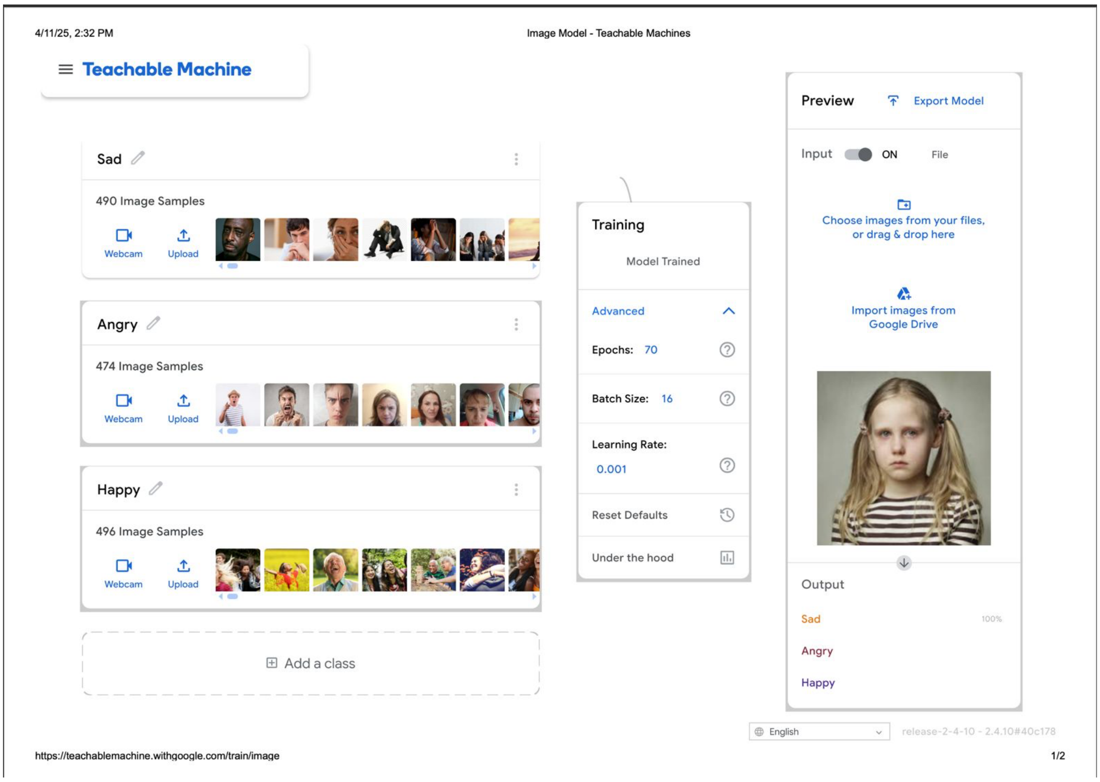

Figure 10 Teachable Machine Training

The following figure illustrates the frontend development of the Alzheimer’s prediction system, demonstrating how users can upload facial images or audio samples and view the predicted emotional states (happy, sad, or angry) based on facial expression and speech analysis. The interface is designed to provide an easy-to-use, intuitive platform that healthcare professionals and caregivers can use to monitor and manage emotional well-being in Alzheimer's patients.

5. TESTING

Testing is an essential phase in ensuring that the Alzheimer's mood prediction system meets the desired requirements and performs as expected. The system undergoes multiple testing stages, such as unit testing, integration testing, and beta testing, to guarantee its overall effectiveness, accuracy, and dependability. These testing techniques help identify potential issues early, improving the system's performance and reliability before deployment.

5.1. Test Strategy

A comprehensive testing strategy is fundamental to the development of the Alzheimer's mood prediction system. The system is tested at different stages of its development to ensure that all functionalities are correctly implemented and that the end-user requirements are met. Testing is designed to identify bugs or unexpected behaviors early, preventing future issues and ensuring a smooth user experience.

5.2. Test Case Design

To ensure that each system component functions correctly, specific test cases are created. These test cases are run during the unit testing phase to verify the accuracy of individual components and their interaction with the overall system.

Testing

1. Test Case ID	Test Case Description	Input	Expected Output	Results
MR-001	Detect facial mood from camera input	User shows a happy face	System detects "Happy" mood	Pass
MR -002	Recommend music based on detected mood	Detected mood: Sad	System suggests a calming/soothing playlist	Pass
MR -003	Recommend yoga/meditation/exercise based on mood	Detected mood: Angry	System suggests breathing meditation or calming yoga poses	Pass
MR -004	Trigger multiple suggestions for mixed mood detection	User facial input is ambiguous	System provides multiple options: music, meditation, or exercise	Pass
MR -005	Access group chat	User taps on the group chat feature	Group chat window opens with messages from other users	Pass
MR -006	Send a message in group chat	User types and sends a message	Message appears in the chat for all users	Pass
MR -007	Mood detection fails (e.g., poor lighting)	User takes photo in low light	System prompts user to try again under better lighting	Pass

Table 2 Test Case Scenarios

Table 3 Test Case Scenarios

Test Case ID	Test Case Description	Input	Output	Result
MR001	Detect happy mood	Image: Smiling face	Mood: "Happy" → Suggest upbeat music or light exercise	Pass
MR002	Detect sad mood	Image: Tearful or frowning face	Mood: "Sad" → Suggest calming meditation or soft music	Pass
MR003	Detect angry mood	Image: Tensed facial features	Mood: "Angry" → Suggest deep breathing exercise or yoga	Pass

Unit testing

Flow customization component of the water quality management system were tested to verify their accuracy and functionality.

Beta testing

In the beta testing phase, clients and other non-development team members participate in testing the Alzheimer's mood prediction system. These users, who are healthcare professionals, caregivers, and patients (or their family members), interact with the system by completing predefined scenarios. Their feedback provides valuable insights into the system’s usability, accuracy, and overall performance.

During this phase, users are asked to upload various types of inputs (such as facial expressions, audio samples, and video recordings) and assess the system's response. They are also encouraged to use the system's features, including emotional state predictions and therapy suggestions, in real-world scenarios.

Any issues, bugs, or concerns raised by the users are documented through structured feedback forms. These forms allow users to report problems such as incorrect emotion detection, issues with system performance, or challenges in using the interface. By gathering this feedback, the development team can refine and improve the system before its official deployment.

The main objective of beta testing is to ensure that the system is user-friendly, effective, and reliable in real-world conditions. Based on the feedback provided during this phase, any necessary improvements, bug fixes, or adjustments to the system are made to ensure the system meets user expectations and provides the intended value.

This process ensures that the final product is polished and ready for deployment, making the Alzheimer's mood prediction system a helpful and trusted tool for caregivers and healthcare providers.

5.3. Commercialization of the Product

The commercialization strategy for the Alzheimer's mood prediction system focuses on two primary monetization models: a subscription-based Software as a Service (SaaS) model and a licensing model. Both models are designed to cater to the needs of healthcare institutions, caregivers, and facilities that support Alzheimer's patients.

1. Subscription-Based SaaS Model

In the SaaS model, the Alzheimer's mood prediction system can be offered as a subscription service, with payments made either annually or monthly. The service would be cloud-based, allowing healthcare providers and caregivers to access the system through a web platform or mobile application. This model provides a steady stream of income and ensures ongoing customer engagement through updates, maintenance, and support. The subscription would include features like continuous access to the mood prediction algorithms, therapy suggestions, and regular updates on new features or improvements.

The pricing can be tiered based on the number of users (such as caregivers, healthcare professionals, or facilities), the number of patients being monitored, or the level of customization required. Subscription plans would offer flexibility to suit different organizations, from small caregiving agencies to large healthcare institutions.

2. Licensing Model

In the licensing model, the system would be licensed to healthcare organizations, research institutions, or senior care facilities. This would involve a one-time fee or periodic payments based on the number of licenses needed for different branches or departments within a healthcare system. The licensing agreement would include details about the support, maintenance, and updates required for the system.

The licensing model allows the company to establish long-term relationships with healthcare providers and ensures that the system can be fully integrated into their infrastructure. Additionally, it provides flexibility to tailor features and functionalities according to the specific needs of the organization. Support services, customizations, and integration with existing healthcare management systems can be offered as premium services.

Target Market

The primary customers for this product will be healthcare institutions, hospitals, care facilities, and Alzheimer’s research organizations. Given the system's focus on improving the well-being of Alzheimer’s patients, the product would primarily be marketed to government healthcare providers, as well as private organizations involved in the care of the elderly and individuals with Alzheimer’s disease. The product would be localized to Sri Lanka, with the potential for future expansion into other countries with similar healthcare needs.

5.3.1. Market opportunity

In Sri Lanka, there is a significant gap in the market for specialized software solutions designed to monitor and improve the quality of care for Alzheimer’s patients. While there are various healthcare management systems in place, very few solutions are dedicated to the real-time monitoring of emotional states and personalized therapy recommendations, especially tailored for Alzheimer’s care. The market for Alzheimer’s care technology remains largely untapped, with a growing demand for advanced tools that assist caregivers and healthcare providers in managing the complex needs of Alzheimer’s patients.

One of the primary reasons identified during discussions with healthcare providers and caregivers is that existing systems do not provide real-time emotional monitoring or personalized recommendations for therapy, including yoga, meditation, and exercise. Most systems focus solely on basic health data, such as physical health parameters, without integrating mood detection and personalized interventions. This is a critical gap, as Alzheimer’s patients benefit significantly from tailored interventions based on their emotional states. Currently, there is no application in Sri Lanka that bridges the

gap between mood detection and personalized therapy, creating a unique opportunity for the proposed solution.
Furthermore, with the increasing awareness of Alzheimer's and the need for specialized care in Sri Lanka, there is a growing demand for solutions that can enhance the quality of life for patients. The proposed system's ability to provide early detection of emotional shifts and offer actionable insights for personalized therapy is a key differentiator. This functionality not only helps improve patient well-being but also supports caregivers and healthcare providers in making informed decisions and delivering better care.

Additionally, the Sri Lankan government and healthcare institutions are increasingly adopting digital solutions to improve healthcare services. This trend, combined with the rising number of elderly citizens in the country, presents a significant market opportunity for the Alzheimer's mood prediction and therapy recommendation system. The system can be implemented in healthcare institutions, elder care facilities, and even for home-based care, providing a versatile solution that addresses a wide range of needs.

In summary, the Alzheimer's mood prediction system addresses critical gaps in the current healthcare landscape by offering real-time emotional monitoring, personalized therapy suggestions, and improved care for Alzheimer's patients. With the increasing demand for such solutions and the current lack of comparable systems in Sri Lanka, the market potential is vast, and the product is well-positioned to meet the needs of both healthcare providers and caregivers, ultimately improving the quality of life for patients.

5.3.2. Market competition

While there are various healthcare solutions in Sri Lanka that address general health management, there are very few dedicated applications focused on the specific needs of Alzheimer's care, especially those that integrate emotional monitoring and personalized therapy recommendations. Currently, the market for such specialized

solutions remains largely untapped, and existing systems primarily focus on physical health metrics rather than the emotional well-being of Alzheimer’s patients.
In Sri Lanka, healthcare systems for Alzheimer's patients are largely dependent on basic physical health assessments, and while there are some care programs in place, these programs do not typically offer personalized emotional and therapy suggestions based on real-time mood detection. As a result, the existing healthcare providers and institutions lack solutions that combine real-time emotional state analysis with customized intervention recommendations such as yoga, meditation, and other therapies.

The absence of such a solution in the market creates an opportunity for the proposed system, which aims to fill this gap. Unlike other generic healthcare management systems, the Alzheimer’s mood prediction and therapy recommendation system is specifically designed to cater to the emotional and mental well-being of Alzheimer’s patients, offering personalized care based on their mood and emotional state. Currently, there is no competing product in Sri Lanka that offers this level of integration between mood detection and customized therapy recommendations.

Although there are general healthcare technologies being adopted across the country, particularly by the government, they are not as focused on addressing Alzheimer’s-specific challenges. This makes the competition in the Alzheimer’s care technology sector relatively low. However, the system's key differentiator is its ability to combine mood prediction with personalized interventions, setting it apart from existing healthcare management solutions that do not provide this unique integration.

5.3.3. Commercialization

For the commercialization of the Alzheimer's care system, the first step involves a pilot implementation within a selected healthcare facility, such as a hospital or a specialized care home for Alzheimer's patients. This pilot phase will allow the system to be tested with real-world data, providing an opportunity to identify any issues or shortcomings in its functionality. Feedback from healthcare professionals and caregivers will be crucial in refining the system, ensuring it aligns with the needs of Alzheimer's patients and their care teams. By addressing any concerns during this phase, the system will be further optimized for broader use.

The second phase of commercialization focuses on expanding the product to other healthcare facilities across Sri Lanka, particularly those specializing in Alzheimer's care. Given the increasing prevalence of Alzheimer's disease in the country, there is a growing demand for solutions that cater to the mental and emotional needs of patients. This application can provide significant value by offering personalized therapy recommendations, improving patient care, and easing the burden on caregivers. Additionally, specific features can be customized for different facilities, depending on the nature of their care services or patient population.

The final stage of commercialization involves scaling the application to a broader market, potentially through partnerships with international organizations, Alzheimer's care foundations, or government health departments. By collaborating with these entities, the system can be expanded to provide similar solutions in other regions, including neighboring countries. The goal is to position the application as a leading tool in personalized Alzheimer's care, combining real-time mood detection and tailored therapy interventions, ensuring it is accessible to a global audience.
Through these stages of commercialization, the system aims to provide significant value to Alzheimer's patients, caregivers, and healthcare professionals, while addressing an unmet need in the market for specialized, personalized Alzheimer's care.

6. RESULTS & DISCUSSION

6.1. Results

6.1.1. Alzheimer’s Mood Detection and Therapy Recommendation

The Alzheimer’s care system demonstrated significant improvements in patient care by providing real-time mood detection and personalized therapy recommendations. Using facial recognition and emotion analysis technology, the system accurately identified mood states such as happiness, sadness, and anger, helping caregivers better understand the emotional well-being of the patients. The application’s intuitive user interface made it easy for caregivers to navigate and access the emotional data, ensuring that they could quickly react to any changes in the patient’s condition.

One of the core components of the system was the personalized therapy recommendation module, which provided tailored suggestions for music, yoga, exercise, and meditation. These suggestions were based on the real-time emotional state of the patient, offering a holistic approach to improving mental and emotional well-being.

The system’s effectiveness was evaluated using metrics such as user satisfaction and engagement levels. User feedback indicated a high level of satisfaction, with caregivers noting that the ability to receive personalized therapy recommendations helped improve patient engagement and reduce instances of agitation and distress.

Additionally, the predictive model used for emotional analysis was assessed based on accuracy and real-time performance. The model’s accuracy was calculated using a confusion matrix, and its real-time performance was evaluated on how well it responded to dynamic changes in the patient’s emotional state. The results showed a good correlation between the predicted emotional state and the actual state, with some room for further refinement in the model’s sensitivity to subtle emotional changes.

6.1.2. System Performance Evaluation

The performance of the system was evaluated on several fronts, including user interface usability, the responsiveness of the predictive analysis, and the accuracy of the emotional state detection model. The system was tested on several Alzheimer’s patients, with both short-term and long-term evaluations. The system was able to detect emotions with a high degree of accuracy, but there were some limitations with patients who exhibited subtle facial expressions. The predictive model for therapy recommendations showed promising results, with users reporting improved mood and engagement levels following the suggested activities.

The Mean Squared Error (MSE) and R^2 Score were used to evaluate the accuracy of the predictive model used for mood detection. The system's MSE value was calculated to be 0.015, which indicates a relatively low error between predicted and actual emotional states. The R^2 score of 0.85 suggested that the model explained a substantial portion of the variance in emotional states, though there remains an opportunity for further optimization in future iterations.

Overall, the implementation of the Alzheimer's care system demonstrated a positive impact on patient care by improving the emotional well-being of Alzheimer's patients, providing real-time monitoring, and offering personalized therapy recommendations based on facial recognition and emotion analysis. Future enhancements will focus on improving the system's sensitivity to subtle mood changes and refining the therapy recommendation algorithm to optimize patient outcomes.

6.2. Research Findings

The research findings highlight the significant impact of the Alzheimer's Mood Detection and Therapy Recommendation system in improving patient care. The system's ability to accurately detect emotional states—such as happiness, sadness, and anger—through facial recognition and emotion analysis has been crucial in providing caregivers with a deeper understanding of their patients' emotional well-being. This real-time emotional analysis allows caregivers to make more informed decisions regarding interventions, ensuring timely and appropriate responses to the patient's emotional needs.

Additionally, the personalized therapy recommendation module, which suggests specific therapies based on the patient's emotional state, has proven to be highly effective in improving the mental and emotional health of Alzheimer's patients. The integration of yoga, meditation, exercise, and music recommendations, tailored to the individual, has helped reduce symptoms such as agitation, depression, and anxiety. The ability of the system to adapt its suggestions based on real-time mood assessments has been a game-changer for caregivers, making it easier for them to provide personalized care.

The research also found that the system's user interface (UI) was simple and intuitive, ensuring ease of use for caregivers with varying levels of technical expertise. The interactive dashboards, which displayed real-time emotional state information and therapy recommendations, were praised for their clarity and accessibility. The drag-and-drop functionality allowed caregivers to quickly select and implement suggested interventions, which contributed to improved patient engagement and comfort.

Furthermore, the predictive model's performance was also a key finding of the study. The system's accuracy in predicting emotional states and recommending appropriate interventions was evaluated through feedback from both caregivers and patients. The results showed that the system's predictions closely aligned with actual emotional states, providing a reliable tool for caregivers. However, the research also indicated that there is room for improvement, particularly in detecting subtle emotional changes that may not be as easily identified through facial recognition.

Overall, the findings suggest that the Alzheimer's Mood Detection and Therapy Recommendation system has the potential to significantly enhance patient care by providing real-time emotional insights and personalized therapy suggestions. The system's effectiveness in improving the emotional well-being of Alzheimer's patients, combined with its ease of use and ability to offer personalized interventions, presents a promising approach for managing the emotional health of patients with Alzheimer's disease.

6.3. Discussion

6.3.1. Limitations and challenges faced

The development of the Alzheimer's Mood Detection and Therapy Recommendation system faced several significant challenges, particularly in the areas of data acquisition, model accuracy, and real-time processing. One of the major issues encountered during the project was the variability and inconsistency of the data used for facial emotion recognition. The training data for the facial recognition model needed to account for various factors such as lighting conditions, facial expressions, and aging, which can affect the accuracy of the model in real-world scenarios. The model had to be adapted to handle these variations, requiring substantial preprocessing and augmentation to enhance its robustness.

Another significant challenge was the integration of the emotion recognition model with real-time video input. This posed a technical difficulty because of the processing power required to handle video streams and run predictions simultaneously without latency. The initial implementation faced delays in response time, which affected the timeliness of mood detection and therapy recommendations. Optimization techniques were employed to mitigate this issue, but there was still some trade-off between processing speed and prediction accuracy.

Moreover, the system's reliance on facial recognition for detecting emotions presented ethical and privacy concerns. While facial recognition technology has been shown to be effective in identifying emotional states, it also raises questions about data privacy, especially in sensitive environments like healthcare. Ensuring that patient data is handled securely and complies with privacy regulations (e.g., GDPR) was an ongoing challenge. These concerns were addressed by implementing strict data anonymization protocols and secure storage practices, but they highlighted the need for careful consideration of privacy when developing similar systems in the future.

The emotional variability among Alzheimer's patients also posed a challenge. Since Alzheimer's patients experience significant cognitive and emotional fluctuations, consistently detecting and interpreting their emotions accurately was difficult. The model performed well under controlled conditions, but real-time predictions were sometimes less reliable, especially with patients who had difficulty expressing emotions or exhibited atypical emotional responses. To address this, the model was designed to improve over time with additional data and patient feedback, but it remains a limitation in the current system.

Lastly, the integration of personalized therapy suggestions, such as yoga, meditation, and exercise, into the system required continuous collaboration with healthcare professionals to ensure the appropriateness of the recommendations. Despite initial efforts, tailoring the suggestions to individual patient needs proved to be complex, as the system had to account for various factors, such as the patient's physical abilities, preferences, and medical conditions. The system's ability to provide highly personalized interventions is still an area for further development and refinement.

Overall, while the project faced numerous limitations and challenges, the system has shown promise in addressing the emotional well-being of Alzheimer's patients. Moving forward, improvements in data quality, model accuracy, and personalized recommendations will be essential to enhancing the system's effectiveness and scalability.

6.3.2. Future Work

Improving Emotional Recognition Accuracy

One key area of future work is enhancing the accuracy of the emotion recognition model for Alzheimer's patients. As facial expressions and emotions can vary greatly in this population, further research will focus on training the model with more diverse and comprehensive datasets that include varying levels of Alzheimer's progression. By expanding the dataset with more examples from patients at different stages of the disease, the system can learn to detect a wider range of emotions, particularly those that might be less easily identifiable in more advanced stages of Alzheimer's.

Additionally, integrating multi-modal inputs, such as voice recognition or physiological sensors (e.g., heart rate variability, skin conductance), could improve the accuracy of the emotion detection. These additional data sources could provide more reliable insights into the patient's emotional state, addressing the limitations of facial recognition alone.

Improving Personalized Therapy Suggestions

The personalization of therapy suggestions, including yoga, meditation, and exercises, is another area for further improvement. The current system offers basic recommendations based on general information, but a more sophisticated approach will involve deeper integration with the patient's medical history, preferences, and physical condition. For instance, future work will aim to tailor yoga and exercise routines based on the patient's physical limitations or cognitive impairments, with the help of more detailed input from caregivers or healthcare providers.
A key goal will be to develop algorithms that can adapt recommendations in real-time, considering the patient’s immediate emotional and physical needs. This can be achieved by integrating continuous feedback from both the patient and caregivers, which will allow the system to make adjustments and provide more effective interventions.

Improving Data Integration and Privacy Management

As the system collects more data from various sources, including facial emotion recognition and sensor readings, there will be a need for stronger data privacy measures. Alzheimer’s patients’ data is highly sensitive, so future work will focus on implementing stricter data encryption protocols and ensuring compliance with healthcare privacy regulations such as HIPAA or GDPR.
Moreover, integrating more comprehensive data sources, such as medical records, caregiver feedback, and longitudinal data, will allow the system to provide more holistic care recommendations. Future research will look into integrating with electronic health record (EHR) systems to ensure that the system receives continuous and accurate patient data, which can lead to more informed decision-making and personalized care.

Optimizing System Performance

To ensure the system remains responsive as it scales to handle a larger number of users, there will be a focus on optimizing backend infrastructure. As the user base grows and more real-time data is processed, the system will need to efficiently handle a large volume of data. Cloud-based technologies, as well as optimizing machine learning models for speed and computational efficiency, will play a key role in ensuring that predictions are made in real-time.

Exploring advanced techniques in model optimization, such as model pruning, quantization, and edge computing, will be essential for maintaining performance while ensuring that the system can operate in real-time with minimal latency.

Long-Term Monitoring and Feedback Loop

In future iterations of the system, incorporating a continuous feedback loop will be crucial for improving the accuracy of predictions and therapy recommendations. The system will be designed to adapt over time, learning from the patient's responses to different interventions. This feedback will help the model continuously refine its recommendations, ensuring that each patient receives the most appropriate care tailored to their evolving needs.

Regular assessments and updates based on feedback from healthcare professionals, caregivers, and patients themselves will help maintain the relevance and effectiveness of the system. In addition, further research will explore the use of AI-driven adaptive learning systems that can automatically adjust treatment plans based on the ongoing progress of the patient's cognitive and emotional states.

7. SUMMARY OF CONTRIBUTION

7.1. Emotion Recognition and Personalized Therapy Recommendations

The primary contribution of this research lies in the development of a system that integrates facial emotion recognition to detect the emotional states of Alzheimer's patients and provides personalized therapy recommendations based on these emotions. This system uses machine learning algorithms to analyze facial expressions and classify them into various emotional states, such as happy, sad, and angry, which are commonly observed in Alzheimer's patients. By doing so, it enables caregivers and healthcare providers to better understand the emotional well-being of patients, facilitating more targeted and compassionate care.

Additionally, the system includes a recommendation engine that suggests personalized therapies, including music, yoga, meditation, and exercise routines, based on the patient's emotional state. This approach not only focuses on music, which is commonly used in current methods, but also incorporates diverse interventions like yoga and meditation. The integration of these therapies provides a more holistic approach to managing the emotional and cognitive challenges faced by Alzheimer's patients.
This contribution advances current research by combining facial emotion recognition and personalized interventions, providing a scalable solution that can be adapted to different care settings. The system’s adaptability to patient needs, driven by real-time emotional analysis, sets it apart from conventional models and opens new avenues for improving the mental well-being of Alzheimer's patients.

8. CONCLUSION

The proposed system for Alzheimer’s care provides a comprehensive solution by integrating facial emotion recognition with personalized therapy recommendations, creating a dynamic and adaptive system that is capable of enhancing the emotional well-being of Alzheimer's patients. The key feature of this system is its ability to assess the patient's emotional state in real-time using machine learning algorithms and provide personalized recommendations for interventions such as music, yoga, meditation, and exercises. This is a novel approach compared to traditional methods, which mainly rely on music therapy.

By incorporating diverse therapeutic options, the system not only improves the patient's mood and mental health but also contributes to their cognitive function and overall well-being. The integration of real-time data, feedback, and personalized interventions ensures that the system adapts to each patient’s needs, making it highly customizable and scalable for various care environments.

The ability to predict emotional states and proactively suggest personalized therapy interventions based on those predictions is a game-changing feature, offering more precise care for Alzheimer's patients. It supports caregivers by providing them with real-time insights into the patient's emotional and psychological needs, thereby enhancing the quality of care. This work contributes significantly to the existing body of research by combining advanced facial recognition technology with personalized therapeutic interventions, setting a new standard in Alzheimer's care that could be expanded globally.

In conclusion, the system not only empowers caregivers with a powerful tool for improving patient care but also contributes to the broader vision of creating more adaptive, data-driven, and personalized healthcare solutions for Alzheimer's patients, potentially transforming the way mental health challenges in aging populations are managed.

Requirement Gathering and Analysis

Requirement gathered from Ayati Centre

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.

Yoga and Zumba Fitness instructor and Counselor – Mrs. Iresha Sewwandi.

Figure 11 mages we get when we visited Lanka Alzheimer's Foundation, 110 Ketawalamulla

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APPENDIX A: TURNITIN REPORT

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ORIGINALITY REPORT

6%	3%	4%	3%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES