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An AI-Powered Application to Enhance Cognitive Health and Provide Caregiver Support for Dementia Patients

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Abstract: Dementia, a slowly progressing nerve disorder, has millions of sufferers around the world. This paper proposes an AI-powered app to promote cognitive health and help to dementia patients' caregivers. The application contains a machine learning model for early dementia detection, preventive advice, location tracking, memory workout, digital brain games, and cognitive rehabilitation tools. Created with Flutter for universal device support and Firebase for backend help, this tool will help enhance the quality of life for patients and lessen the burden on caregivers. A new evaluation methodology and comparative analysis prove its effectiveness.

Keywords— Dementia Care (DC); Serious Games (SG); Cognitive Assessment (CA); Real-Time Location Tracking (RTL); Machine Learning (ML); Artificial Intelligence (AI); Healthcare Applications (HA); Preventive Care (PC); Cognitive Rehabilitation (CR); Predictive Analytics (PA); GPS Monitoring (GPS); Early Diagnosis (ED); Cross-Platform Development (CPD); User Experience (UX); Responsive Design (RD); Mobile Health (mHealth); Android Application Development (AAD); Dart Programming Language, Flutter Framework (FF); Firebase Integration (FI); Version Control Systems; Deep Learning Frameworks.

I. INTRODUCTION

Due to the development our societies are experiencing dementia and other cognitive impairments become more and more a problem in the public health sector. Dementia, which is caused by cognitive decline, involves millions of people all over the world and creates issues both for the patients and for the caregivers. The traditional methods of care require a lot of resources and are often not available. The paper presents the AI mobile application that is able to detect early, monitor in real-time and provide individualized cognitive support. For instance, while smart analytics identifies the risks, through the use of interactive games and location tracking, the disease can be managed holistically thus, improving accessibility and effectiveness in dementia care.

As our society advances, the prevalence of dementia and other cognitive impairments is becoming an increasingly significant public health concern. Dementia, characterized by the deterioration of cognitive functions, affects millions of individuals worldwide. The current methods of dementia care are often resource-intensive and may not be accessible to everyone, underscoring the need for innovative solutions that leverage modern technology. Artificial intelligence (AI) and mobile health (mHealth) technologies offer promising avenues to enhance dementia care through early detection, personalized support, and improved management. The proposed project aims to develop an AI-powered mobile application designed to support dementia patients and their caregivers. The application will predict the likelihood of dementia based on user-input parameters and provide a comprehensive suite of tools to improve cognitive function, ensure patient safety, and facilitate routine management. By integrating predictive analytics, cognitive exercises, and real-time monitoring, this application seeks to transform dementia care, accessible and responsive to the needs of both patients and caregivers.

II. LITERATURE SURVEY

The integration of artificial intelligence (AI) into healthcare has led to transformative advancements, particularly in rehabilitation and dementia care. This literature review synthesizes insights from recent studies, highlighting the impact, challenges, and future directions of AI-powered solutions in these domains.

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Khalid et al. [1] provide a comprehensive overview of AI-powered solutions in the rehabilitation process, emphasizing recent improvements and future trends. The authors discuss the role of AI in personalizing therapy, monitoring progress, and enhancing patient outcomes. Key advancements include machine learning algorithms for movement analysis and AI-driven devices like exoskeletons that aid mobility. However, the authors also point to challenges such as ethical concerns, data privacy, and the need for interdisciplinary collaboration to optimize these technologies. Velagaleti et. al [2] explores the feasibility and acceptability of an AI-powered virtual reality (VR) and augmented reality (AR) platform for cognitive rehabilitation, specifically targeting patients with Alzheimer's disease and dementia. The study demonstrates that such platforms can improve cognitive engagement and reduce caregiver burden. Despite these benefits, the research identifies barriers such as the high cost of technology, the digital divide, and the need for user-friendly interfaces tailored to older adults. Milella, Russo, and Bandini [3] systematically review AI-powered solutions designed to support informal caregivers in their decision-making processes. The authors highlight tools that provide personalized care recommendations, monitor patient health, and predict potential health deterioration. These solutions have shown promise in reducing caregiver stress and enhancing decision-making efficiency. The review also notes that caregiver training and integration into care workflows remain critical for successful adoption.

Hasan et al. [4] introduce a novel conversational AI approach to empower caregivers of Alzheimer's patients. This solution provides real-time, personalized communication support and fosters better caregiver-patient interactions. The study underscores the potential of conversational AI to improve caregivers' emotional well-being and patients' quality of life, while also emphasizing the importance of ensuring culturally sensitive and ethically sound AI applications. Su et al. [5] examine the intersection of 6G and AI technologies for dementia care, offering a forward-looking analysis of how next-generation connectivity can enhance AI applications. The authors identify potential use cases such as continuous health monitoring, predictive analytics, and remote interventions. They also highlight challenges, including infrastructure requirements, cybersecurity risks, and the need for regulatory frameworks to ensure equitable access.

Kim, Han, and Bae [6] focus on the transformative potential of large language models (LLMs) in Alzheimer's digital caregiving. The study illustrates how LLMs can facilitate personalized care planning, symptom tracking, and caregiver education. The authors call for further research to address limitations such as data bias and the interpretability of AI outputs. Kale et al. [7] explore AI-driven innovations for Alzheimer's disease, emphasizing early diagnosis, personalized treatment, and prognostic modeling. The study highlights advancements in deep learning techniques for analyzing medical imaging and biomarkers. These tools have significantly improved diagnostic accuracy and enabled the development of individualized treatment plans. However, the authors caution that ethical considerations and the integration of AI into clinical practice require careful attention. Tomar et al. [8] provide a comprehensive exploration of AI-powered diagnostic tools for Alzheimer's detection and prediction. Their work highlights the potential of AI to analyze multimodal data, such as imaging, genomics, and clinical records, to achieve early and accurate diagnoses. They also stress the importance of developing scalable and accessible diagnostic solutions to benefit diverse patient populations.

III. Proposed Dementia Care Application Design

This section outlines the key strategies and improvements incorporated into the proposed dementia care application to enhance quality, performance, precision, safety, progress tracking, and real-time functionality.

To enhance quality, the application offers a personalized user experience by dynamically adjusting the difficulty levels of cognitive games and exercises based on user performance. This approach keeps patients engaged without causing overwhelm or boredom. Prediction models leverage diverse inputs such as medical history, demographic data, and lifestyle factors to provide tailored and accurate risk assessments. The comprehensive feature set integrates detection, prevention, rehabilitation, and caregiver support tools into a unified platform for dementia care. Enriched with educational content, reminders, and community support features, the application promotes sustained engagement and overall user satisfaction. Additionally, real-time feedback mechanisms on patient activities like game performance and medication adherence empower caregivers to intervene proactively, improving outcomes. User surveys and in-app feedback channels further ensure that the application evolves to meet caregiver needs. Performance is enhanced through machine learning model optimization, with the Random Forest model via hyperparameter tuning. Regular model evaluation and retraining on updated datasets enable the system to adapt to changing patient data, ensuring robust performance. Efficient backend systems, powered by Firebase, provide real-time data synchronization and secure storage, delivering low latency and high reliability even under heavy usage. Load balancing techniques are implemented to handle peak traffic, especially during emergencies, ensuring uninterrupted service.

The system's real-time GPS tracking capabilities are achieved through Firebase integration, which continuously updates patient locations and synchronizes this data with caregivers. Secure location data storage ensures privacy while offering instant access to authorized users. Geofencing features allow caregivers to define safe zones for patients, triggering immediate alerts if these zones are breached. GPS data is updated every five seconds to maintain accuracy while optimizing battery usage. Backup location services, such as cell tower triangulation, ensure reliable tracking even in areas with weak GPS signals. Precision is a key focus, achieved through Artificial Neural Networks to detect complex patterns in patient data. Data augmentation methods improve model robustness against imbalanced datasets. Preprocessing steps, including data validation and cleaning, mitigate the effects of outliers, missing values, and noise, ensuring the accuracy of predictions. Regular audits of patient data further enhance the application's precision and reliability. Tracking progress is facilitated through cognitive progress reports that monitor patients' performance in cognitive games and

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MMSE assessments on a weekly basis. Visual dashboards allow caregivers to identify trends and areas requiring intervention. These reports also track adherence to medication schedules and participation in rehabilitation exercises. Automated scoring and analysis of cognitive assessments provide actionable insights for caregivers and healthcare providers, enabling informed decision-making and personalized care planning. Safety is prioritized through real-time alerts for events such as geofence breaches, missed medications, or unusual behavior patterns. These alerts are delivered instantly via push notifications to caregivers. Robust encryption ensures compliance with privacy regulations like GDPR and HIPAA, safeguarding patient data. User authentication mechanisms, such as two-factor authentication, protect against unauthorized access. Future enhancements include integrating accelerometer data from wearable devices for fall detection and implementing anomaly detection algorithms to flag sudden changes in patient behavior, enabling timely interventions.

IV. Proposed System Architecture

The proposed system architecture (fig. 1) is structured into four primary layers to ensure seamless operation and user engagement. The User Interface Layer provides intuitive access through features such as login and sign-up, along with distinct tabs for detection, prevention, and rehabilitation. The Detection Tab Components incorporate input parameters like age, gender, genetic predispositions, cognitive test scores, and lifestyle factors. These are processed through machine learning models that utilize structured data and feature extraction techniques to predict dementia risk accurately. At the core, the system employs a hybrid model combining a Feedforward Neural Network (FNN) and ResNet-50, achieving an accuracy of 83.5% on a dataset of 10,000 patient records. The Prevention and Rehabilitation Tab Components include tools for healthy habit education, location tracking, medication reminders, and engaging cognitive activities such as memory games and books, all aimed at enhancing patient outcomes and caregiver support. Supporting these functionalities is a robust Backend System, which leverages Firebase for secure data management, real-time synchronization, and encryption to maintain patient confidentiality.

The system's workflow (fig. 2) begins with Data Collection, gathering information such as demographics, cognitive test scores, and lifestyle factors from patients and caregivers. This data undergoes Preprocessing to clean and organize it, followed by Data Splitting into training (80%) and testing (20%) subsets. During the Classification phase, the hybrid model integrates the FNN and ResNet-50 to analyze features and predict dementia risk. Critical factors are identified during Feature Selection, focusing on elements like age, cognitive test scores, and medical history. The model is then trained and optimized to achieve high accuracy. Finally, the system outputs detailed risk assessments and insights for caregivers and healthcare providers, supporting personalized interventions and informed decision-making.

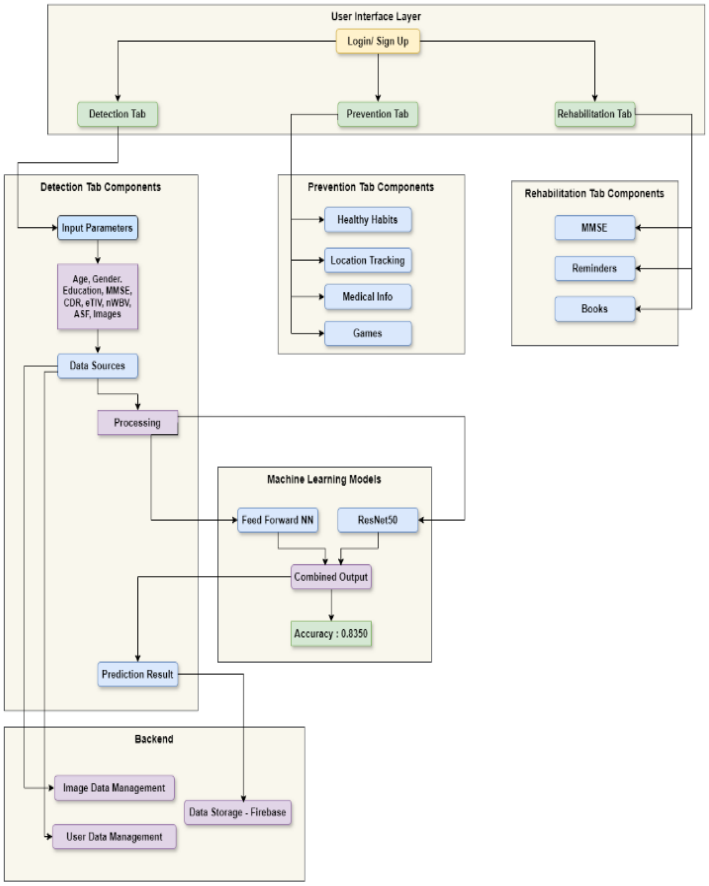

Fig 1. System Architecture of a Dementia Support Application

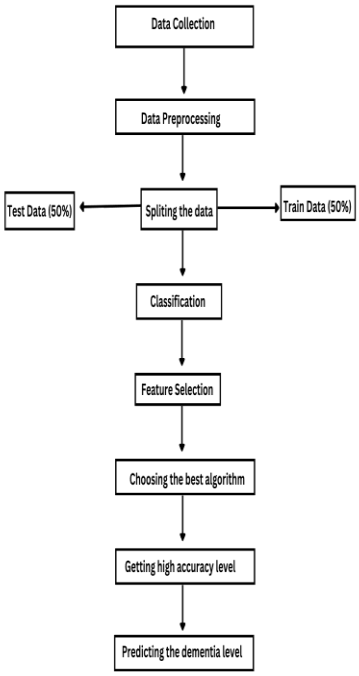

Fig 2. Workflow for Dementia Level Prediction

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V. Implementation of Mobile Application

The proposed mobile and web application, CareMe, is designed to enhance cognitive health and provide caregiver support for dementia patients. The application integrates various features aimed at improving cognitive function, facilitating rehabilitation, and supporting caregivers in managing patient care. The results of the implementation are summarized below:

5.1 Mobile Application Implementation

5.1.1 Welcome and Navigation Interfaces:

Fig 3: Welcome Screen of the CareMe App

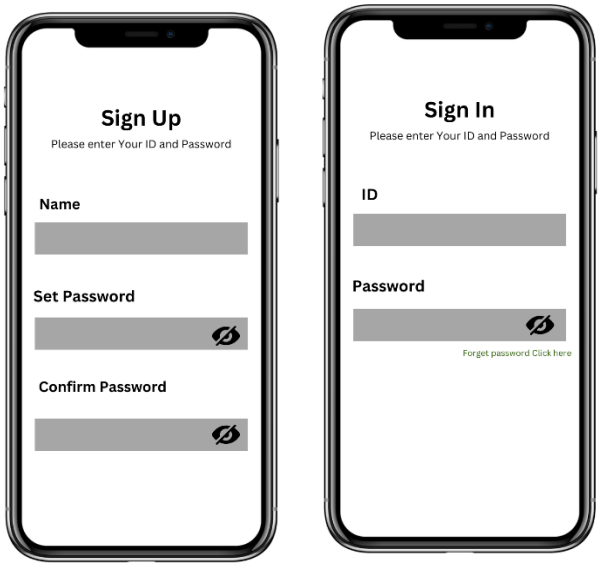

Fig 4: User Registration and Login Interface

Figures 3 and 4 : The welcome screen introduces users to the CareMe app with a simple and user-friendly interface, offering options to either "Get Started" or log in if the user already has an account.

The registration and login interfaces ensure secure access through the creation of personalized accounts by entering a name, ID, and password. Password visibility toggles enhance usability.

5.1.2 Core Functionalities:

Figure 5: The overview screen categorizes the app's functionalities into three main modules: detection, prevention, and rehabilitation, ensuring targeted interventions for users. A built-in GPS tracking feature provides navigation support, enhancing patient safety.

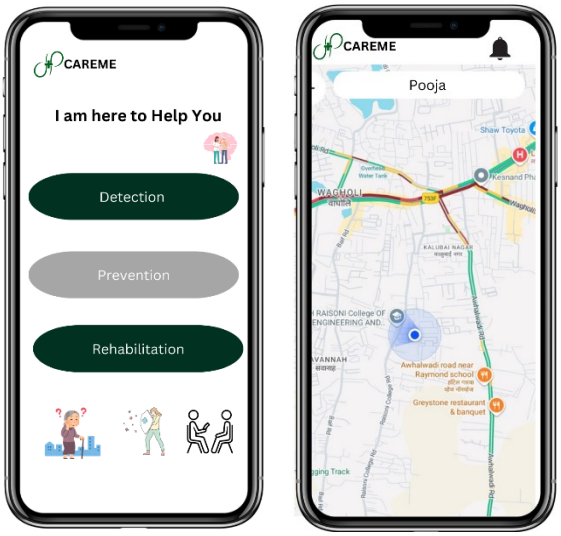

Fig 5: Overview of the CAREME mobile application

5.1.3 Interactive Cognitive Exercises:

Figures 6(a) and 6(b): The cognitive training module includes word-based puzzles such as word selection and word formation tasks, aimed at improving linguistic and problem-solving abilities. *Figure 7:* An ocean-themed word search game further supports cognitive stimulation in an engaging and interactive manner.

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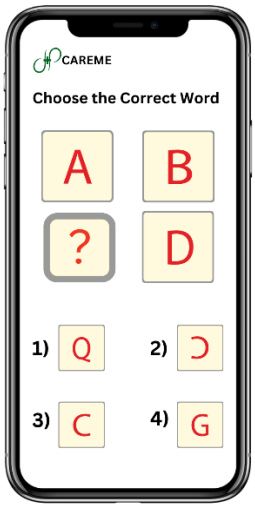


Figure 6 a) Word Selection Puzzle

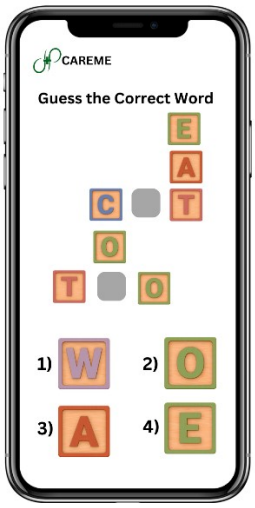


Figure 6 b) Word Formation Puzzle

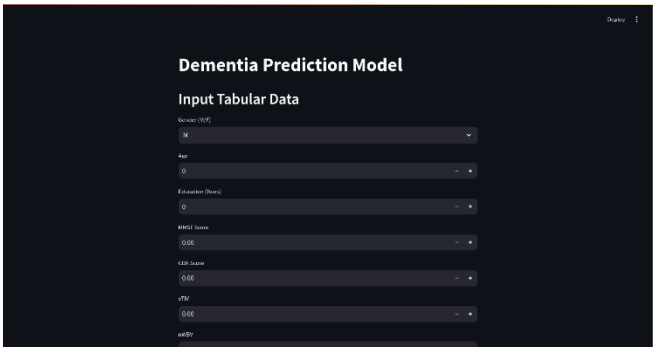
Figure 7 Ocean-Themed Word Search

5.1.4 Clinical and Caregiver Tools

Figure 8: A Mini-Mental Examination feature facilitates early detection of cognitive decline through questions targeting memory and orientation.
Figure 9: The tabular input form allows caregivers to enter and manage patient information efficiently.

Figure 10: A hybrid model leveraging FNN and ResNet-50 architectures is incorporated for processing MRI images. Users can upload MRI scans, which are analyzed to predict dementia risk, ensuring accurate and timely intervention.

Figure 8: Mini-Mental Examination Questions



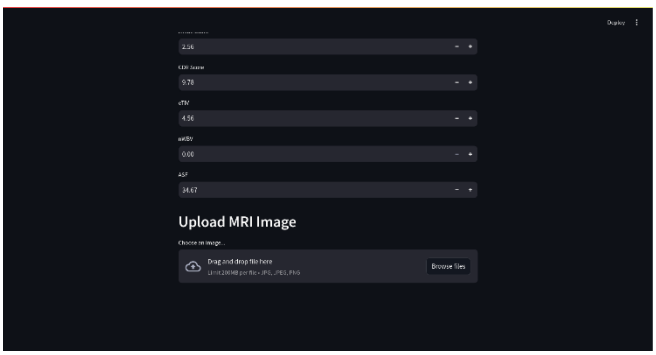


Figure 9 Tabular Input Form

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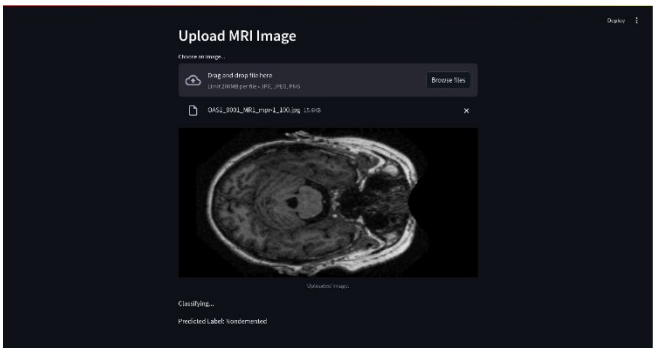

Figure 10 MRI Upload and Prediction

VI. CONCLUSION

The proposed AI-powered dementia care application successfully integrates predictive analytics, cognitive rehabilitation, and real-me monitoring into a unified platform. The hybrid model combining FNN and ResNet-50 ensures accurate dementia risk prediction, while features like cognitive games, medical reminders, and GPS tracking enhance patient safety and quality of life. Additionally, caregiver support tools reduce the burden of care, making this app a comprehensive solution for dementia management.

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