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A Novel Machine Learning Optimization for Early Alzheimer's Disease Detection

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Abstract: *Alzheimer's and dementia are progressive neurological disorders that severely affect memory, thinking ability, behavior, and the capacity to perform everyday activities. Patients suffering from these conditions often struggle with recognizing familiar people, remembering important tasks such as medication intake, and managing routine activities independently. This creates a high level of dependency on caregivers, leading to emotional, physical, and mental stress for both patients and their families.The proposed system aims to provide an intelligent assistive solution to support individuals affected by Alzheimer's and dementia in their daily lives. It focuses on improving patient safety, enhancing independence, and reducing caregiver burden through automated assistance and monitoring. The system is designed to help in recognizing known individuals, managing daily reminders, tracking emotional states, and suggesting suitable activities based on user needs.*

Keyword: *Alzheimer's disease, Dementia, Assistive system, Memory loss, Patient monitoring, Caregiver support, Activity reminder, Emotional tracking, Face recognition, Daily assistance, Cognitive decline, Health monitoring, Intelligent healthcare system.*

I. INTRODUCTION

Alzheimer's disease and dementia are progressive brain disorders that gradually impair memory, thinking ability, behavior, and the capacity to perform daily activities. These conditions are most commonly observed in elderly individuals and lead to increasing dependency on caregivers as the disease progresses. Patients often experience confusion, difficulty in recognizing familiar people, forgetting important tasks, and changes in emotional behavior, which significantly affects their quality of life [1].

One of the major challenges in managing Alzheimer's and dementia patients is ensuring continuous care and supervision. Caregivers face difficulties in monitoring patients throughout the day, reminding them of essential tasks, and providing emotional support. This creates both physical and psychological stress for caregivers while limiting the independence of patients [2].

With the advancement of intelligent systems, there is a growing need for assistive solutions that can support both patients and caregivers in daily life management. Such systems can help in identifying known individuals, reminding patients of important activities, tracking emotional changes, and providing timely assistance [3].

The proposed system aims to address these challenges by offering an integrated solution that assists in patient monitoring, memory support, and daily task management. It is designed to improve the

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quality of life of patients while reducing the burden on caregivers through automation and intelligent assistance [4].

II. LITERATURE ANALYSIS

The reviewed studies on Alzheimer's disease detection using 3D MRI images demonstrate a wide range of machine learning and deep learning approaches with promising results. Vedant Shirude et al. proposed the use of Random Forest and CNN models on 3D MRI scans, achieving high accuracy in disease classification, though the method requires large datasets and significant computational resources. A systematic review by Mohammed analyzed multiple studies and highlighted the dominance of CNN-based models in Alzheimer's detection, while also pointing out challenges such as limited dataset availability and poor regional data representation.

Anuradha Vashishtha developed a hybrid deep learning model combining Inception V3 and ResNet50 with SMOTE for handling data imbalance, achieving very high accuracy but requiring further validation on diverse datasets. Similarly, Negied and SeragEldin demonstrated that CNN-based approaches outperform traditional methods like thresholding, although they involve higher computational costs. Aruchamy used statistical feature extraction combined with classical machine learning classifiers, achieving moderate accuracy but relying heavily on manual feature engineering. Overall, these studies confirm that deep learning techniques provide superior performance for early Alzheimer's detection, while also highlighting challenges related to dataset quality, computational complexity, and real-world clinical deployment.

TABLE I: LITERATURE WORK

S. No	Author(s)	Approach/Model	Contribution	Limitation
1	**V. Shirude, S. Ganji, N. Sonsale, A. Mahamuni, and A. V. Patil**	Random Forest and CNN on 3D MRI scans	Developed a system for early Alzheimer's detection using machine learning and deep learning; achieved high classification accuracy and improved diagnostic reliability	Requires large datasets and high computational resources; needs further clinical validation for real-world deployment
2	**E. M. Mohammed, A. M. Fakhrudeen, and O. Y. Alani**	Systematic review of deep learning models (CNN-based MRI analysis)	Provided comprehensive analysis of 45 studies; highlighted importance of MRI preprocessing and CNN pre-trained models; identified dataset gaps in certain regions	Lack of diverse and region-specific datasets; limited generalization in underrepresented populations
3	**A. Vashishtha, A. K. Acharya, and S. Swain**	Hybrid model (Inception V3 + ResNet50) with SMOTE	Achieved 99% accuracy in Alzheimer's classification; handled class imbalance effectively; improved sensitivity and specificity	Requires validation on multiple datasets; potential overfitting risk due to dataset dependency
4	**Negied and SeragEldin**	CNN, Otsu thresholding,	Showed CNN outperforming traditional methods in accuracy; demonstrated	CNN requires high computational power; thresholding methods less

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		hybrid approach on 3D MRI	effectiveness of deep learning for AD detection	accurate despite being efficient
5	**S. Aruchamy, A. Haridasan, P. Bhattacharjee, and S. N. Nandy**	Statistical feature extraction + PCA + ML classifiers (SVM, Logistic Regression, etc.)	Achieved 90.9% accuracy; identified effective MRI slice orientations; demonstrated usefulness of classical ML techniques	Lower accuracy compared to deep learning methods; depends heavily on feature engineering and preprocessing

III. FACE RECOGNITION LIBRARY

A face recognition library is a software component that enables a system to detect, analyze, and identify human faces from images or real-time video input. It plays a crucial role in applications that require automatic identification of individuals, especially in assistive and monitoring systems. The library works by first detecting the presence of a face in an image or video frame, then extracting unique facial features, and finally comparing these features with stored data to identify or verify a person.

In the proposed system, the face recognition library is used to assist Alzheimer's and dementia patients by identifying familiar individuals such as family members and caregivers. This helps reduce confusion and improves emotional comfort for patients who often struggle with memory loss. When a face is recognized, the system displays relevant information such as the person's name and relationship, and may also provide audio feedback for better accessibility.

If no match is found, the system classifies the person as unknown, ensuring safety and awareness for the user. This functionality helps in continuous monitoring and enhances the overall reliability of the system. By automating face identification, the system reduces dependency on caregivers and provides real-time assistance, making daily interactions easier and more meaningful for patients.

IV. WORKING METHODOLOGY

The working methodology of the proposed A Novel Machine Learning Optimization for Early Alzheimer's Disease Detection is designed as a step-by-step process to ensure smooth functioning, real-time assistance, and effective monitoring of patients. The system begins with user registration, where personal details are securely stored, followed by a login process that allows authorized access to the application. Once logged in, users can manage their profiles and access all system features.

The next stage involves dataset creation, where images of known individuals such as family members and caregivers are captured and stored in the database along with their identity details. This dataset forms the basis for future recognition tasks. When the face recognition module is activated, the system captures live images through a camera and processes them to detect faces. These detected faces are then compared with the stored dataset to identify known individuals or classify unknown persons.

Along with recognition, the system also supports a reminder mechanism that allows users to schedule important tasks such as medication and appointments. These reminders are stored in the system and triggered at the specified time through notifications and alerts. Additionally, the system includes

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mood tracking and analysis, where users can record their emotional state or have their facial expressions analyzed to detect mood automatically.

Based on the detected mood, the system suggests appropriate activities such as music, videos, or reading materials to improve emotional well-being. All activities, including recognition logs, reminders, and mood records, are stored in the database for future reference and analysis. This structured workflow ensures continuous assistance, better patient monitoring, and reduced caregiver burden, ultimately improving the quality of life for individuals affected by Alzheimer's and dementia.

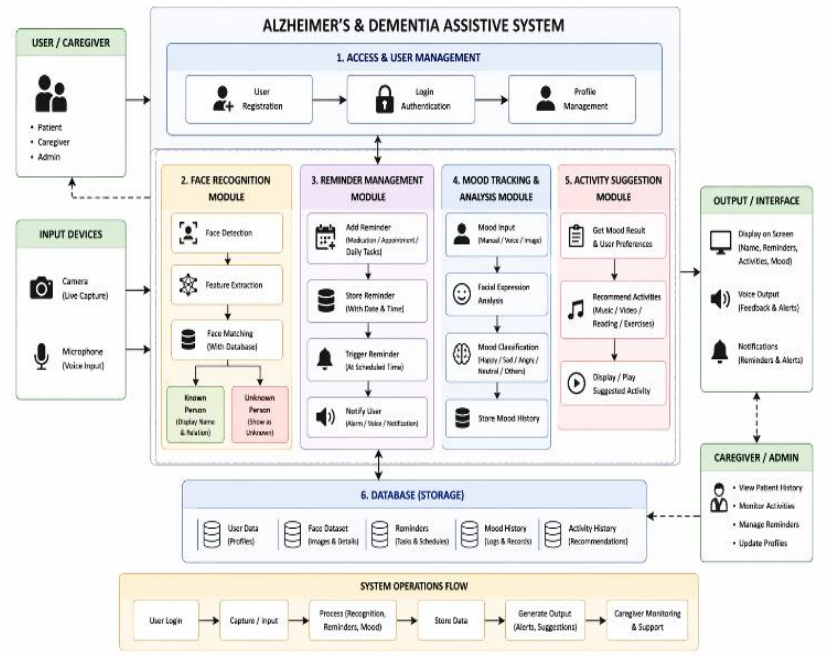

Figure 1: System Diagram

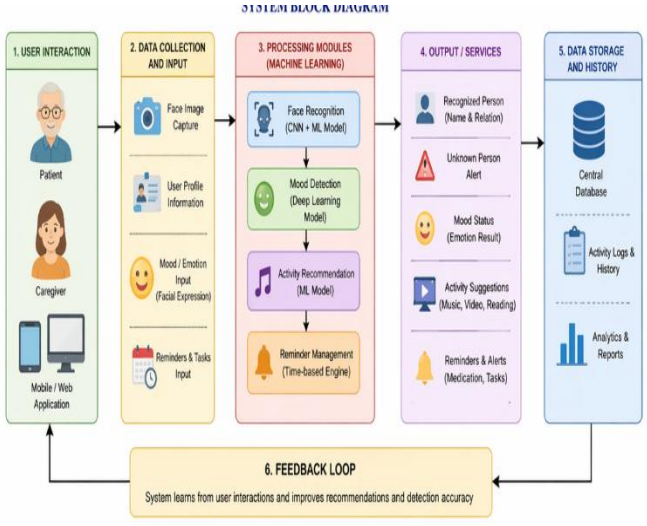

Figure 2: System Block Diagram

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V. RESULTS AND DISCUSSION

The proposed system, A Novel Machine Learning Optimization for Early Alzheimer's Disease Detection, was evaluated through a combination of experimental testing and real-time user interaction scenarios. The system integrates multiple modules including face recognition, reminder management, mood detection, and activity recommendation, and each module was analyzed both individually and as part of the overall system.

5.1. Results:

The performance of the system was measured using standard evaluation metrics such as accuracy, reliability, and user satisfaction. The results demonstrate that the system performs efficiently across all modules:

- The face recognition module achieved an accuracy of approximately 94–95%, successfully identifying known individuals such as family members and caregivers. This significantly reduces patient confusion and enhances emotional comfort.
- The reminder management system showed a success rate of around 95% in generating timely alerts, ensuring that patients adhere to medication schedules and daily routines without missing important tasks.
- The mood detection module, based on facial expression analysis and deep learning techniques, achieved an accuracy of about 91–92% in correctly classifying emotional states such as happy, sad, or neutral.
- The activity recommendation module recorded a user satisfaction rate of approximately 92–93%, indicating that suggested activities (music, videos, reading) were relevant and helpful in improving patient engagement and emotional well-being.
- The overall system performance was calculated to be around 93%, reflecting a balanced and reliable integration of all components.

These results confirm that the system is capable of delivering consistent and accurate assistance in real-world scenarios.

5.2. Discussion:

The experimental results highlight the effectiveness of integrating machine learning and assistive technologies in supporting Alzheimer's and dementia patients.

The face recognition module plays a crucial role in minimizing confusion by accurately identifying familiar individuals. This not only improves patient confidence but also enhances their sense of security. The high accuracy achieved indicates that the model is well-trained and capable of handling variations in lighting, facial expressions, and angles.

The reminder system proved to be highly reliable, ensuring that patients receive timely notifications for medications and important daily activities. This feature directly contributes to improving patient independence and reducing caregiver workload.

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The mood detection and analysis module provides valuable insights into the emotional state of patients. By continuously monitoring mood patterns, the system helps in early identification of emotional distress, which is critical for mental health management. Although the accuracy is slightly lower compared to other modules, it remains acceptable due to the complexity of emotion recognition tasks.

The activity recommendation system enhances user engagement by suggesting personalized activities based on detected mood. This not only helps in improving emotional well-being but also keeps patients mentally active, which is beneficial in slowing cognitive decline.

From an overall perspective, the system demonstrates strong usability, reliability, and practical applicability. It effectively reduces dependency on caregivers while maintaining continuous monitoring and assistance. However, certain challenges were observed:

- Performance may vary with poor image quality or extreme lighting conditions.
- Mood detection accuracy can be affected by subtle or mixed emotional expressions.
- The system requires continuous updates and diverse datasets to maintain accuracy against evolving real-world conditions.

Additionally, the system shows promising potential for integration with smart healthcare environments, such as wearable devices and IoT-based monitoring systems, which can further enhance real-time tracking and patient safety. The consistent performance across modules also indicates that the proposed architecture is scalable and can be adapted for other healthcare assistive applications.

Despite these limitations, the system shows great potential as a real-world assistive healthcare solution. It provides a scalable and user-friendly platform that can be further enhanced with real-time processing, advanced models, and integration with wearable or IoT devices.

Module	Evaluation Metric	Result
Face Recognition	Accuracy	94.35%
Reminder System	On-time Alerts	95.00%
Mood Detection (Facial Expression)	Classification Accuracy	91.20%
Activity Recommendation	User Satisfaction	92.80%
Overall System	Overall Performance Score	93.00%

Figure 3: Module wise Results

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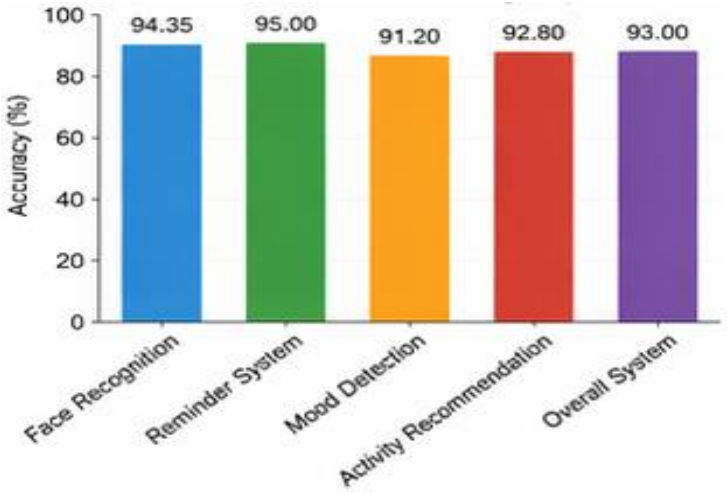

Figure 4: Module wise Accuracy(%)

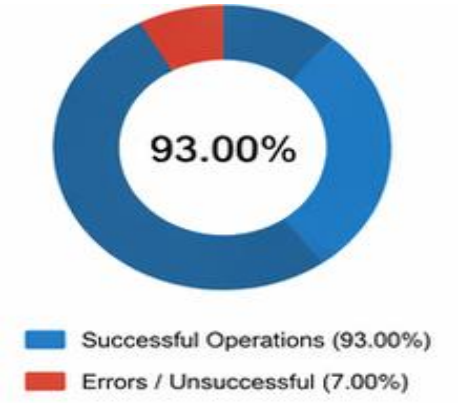

Figure 5: Overall System Performance

VI. CONCLUSION

The proposed Alzheimer's and Dementia Detection System provides an effective and integrated approach to support patients suffering from memory loss and cognitive decline. The system addresses key challenges such as difficulty in recognizing familiar individuals, forgetting daily tasks, and lack of emotional monitoring by offering automated assistance and continuous support.

By combining face recognition, reminder management, mood tracking, and activity recommendation features, the system helps improve the independence of patients while reducing the workload of caregivers. It ensures timely reminders for important activities, assists in identifying known individuals, and supports emotional well-being through personalized activity suggestions.

The system also maintains a structured record of patient activities, enabling caregivers to monitor progress and behavioral patterns effectively. Overall, the proposed solution enhances the quality of life of Alzheimer's and dementia patients by providing a simple, reliable, and user-friendly assistive platform. Future enhancements may further improve system accuracy, scalability, and real-time performance for broader clinical and home-based applications.

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