

Digital Health Innovations for Dementia Care : A Mobile-Based Approach

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Abstract: *Dementia care poses significant challenges for patients, caregivers, and healthcare systems globally. Conventional approaches based on in-person consultations and manual assistance are often inefficient, resource-intensive, and difficult to scale with increasing prevalence. This paper provides recent advancements in mobile health (mHealth) technologies aimed at automating and personalizing dementia support. Emerging studies highlight the use of artificial intelligence and machine learning models for adaptive cognitive training and assistance in daily activities. Additionally, GPS and sensor-based systems have shown effectiveness in real-time safety monitoring. Research also emphasizes improving caregiver integration within digital care frameworks. Despite these developments, a gap persists between user needs and existing technological capabilities. Key challenges include data privacy concerns, usability issues, and limited system integration. This outlines current progress and identifies future directions for developing reliable, scalable, and user-centered dementia care solutions..*

Keywords: GPS tracking, memory exercises, dementia care, patient health, assistive technology, cognitive stimulation, and caregiver support

I. INTRODUCTION

Particularly for Alzheimer's disease, the most prevalent form of dementia, effective dementia management is crucial for enhancing patient independence and lowering caregiver stress [1]. Cognitive decline, medication adherence problems, safety hazards, and mounting financial strains are just a few of the major obstacles facing the healthcare system [2]. These issues are exacerbated by ineffective monitoring and support systems; according to reports, over 55 million people worldwide suffer from dementia, which costs more than \$1.3 trillion annually [3]. With estimates indicating potential savings in the trillions and a notable improvement in care quality, digital solutions are essential to addressing these persistent problems [4].

Traditional dementia care has long depended on antiquated techniques that are challenging, time consuming, costly, and frequently unreliable [5]. These approaches are slow, inaccurate, and frequently mentally taxing because they rely on manual evaluations, paper records, and clinicians' subjective assessments [5][6].

Therefore, there is a critical gap in a framework that can accurately measure partial care adherence while still being user-friendly for non-expert users, such as patients and family caregivers. Many advanced machine learning models are developed without consideration for deployment on low-barrier, easily accessible platforms that are appropriate for caregivers without technical knowledge. By creating a machine learning powered mHealth application based on a hybrid cognitive behavioral framework specifically designed to automate comprehensive support for dementia components, this study addresses these challenges. Additionally, this paper describes how to implement the improved model on a smooth, cloud-based platform, making advanced care tools practical for daily use.

II. LITERATURE REVIEW

From basic manual consultations to sophisticated mobile health and AI-powered platforms, digitally assisted dementia care has changed over time. Basic visual aids and reminder systems were the main focus of early efforts. More recent methods combine networks for caregivers, machine learning, and flexible interfaces to offer comprehensive, continuous



support. Traditional care methods, early digital interventions, cognitive and medication management solutions, and safety monitoring frameworks are the four main themes that this paper unifies a variety of contributions under.

Conventional Approaches to Dementia Care Innovative methods tracked patient progress using static tools, paper logs, and in-person therapies. These were categorized by Astell et al. (2019) [2] into a. Patient-centered monitoring, which looks for deviations by comparing observed behaviors to accepted clinical benchmarks. b. Caregiver supervision, which looks at interactions and routines to gauge the wellbeing and efficacy of support. Although these techniques enhanced basic tracking, they were constrained by manual labor, technological and interpersonal gaps, and scaling problems. For example, using schematic logs (such as "checkboxlist" icons) to demonstrate adherence became commonplace, but there were still limitations to real-time, independent evaluation of care status. [2,10].

Techniques for Digital Processing and Machine Learning Digital processing and machine learning (ML) were used to replace human oversight with algorithms. An ML-based cognitive trainer was developed by Hill et al. (2017) to identify memory lapses in a corpus of 1,200 simulated sessions. Through integrated analytics, their paradigm produced automated insight reports and achieved precision of over 75% [3]. This investigation demonstrated that cost-effective machine learning tools such as natural language processing and adaptive algorithms could provide domain-specific assistance with respectable accuracy. However, it was limited to specific aspects (like memory recall), and it was difficult to scale to more extensive care phases. Furthermore, the robustness of these ML-centric techniques is limited by the lack of large, consistent datasets. [1-9].

Synthesis and Research Gaps The progressive literature traces a clear developmental arc: From traditional documentation (Astell et al., 2019) [2]. To ML-based discernment of discrete tasks (Hill et al., 2017) [3] · To activity-level semantic parsing (Manera et al., 2017) [5]. Toward holistic reviews of mHealth emphasizing clinical fusion (Kamimura et al., 2018) [2]. However, notwithstanding these leaps, sundry voids persist. Generalization across dementia stages (mild, moderate, severe) is scant; most models train for niche tasks. Ethical safeguards and privacy audits are infrequently woven into care monitoring. Processing velocity hampers scalability and real-time deployment. Dataset hurdles abound, with few large-scale, standardized corpora for multi-stage care tracking.

Integration for Clinical Alignment and Reporting After conducting a thorough evaluation of mHealth applications for dementia supervision, Kamimura et al. (2018) concluded that utilities [2] could be primarily divided into three categories: Using longitudinal data (such as activity trackers and sensor fusion) to identify patterns in behaviour is known as predictive analytics. Resource Detection and Logging: identifying and tracking the use of tools such as prescription drugs or routines. Behavioural Segmentation: Using app interactions to define care at an activity level [4]. By drawing a comparison between planned care protocols and ongoing as is profiles, they highlighted the growing significance of clinical integration. There are still issues with processing latency, adaptability to different user scenarios, and the lack of annotated datasets.

III. PROBLEM STATEMENT AND OBJECTIVES

Dementia patients and their caregivers face challenges in managing daily activities, ensuring medication adherence, and responding to emergencies in a timely manner. Traditional care methods rely heavily on manual monitoring and lack real-time coordination between patients, caregivers, and emergency services, leading to inefficiencies, delayed responses, and reduced quality of care.

Objectives:

- To develop a mobile application that provides task reminders, medication alerts, and cognitive exercises for dementia patients.
- To enable voice command functionality and an emergency (SOS) feature for easy and quick access by patients.
- To design a caregiver interface for scheduling tasks, monitoring patient activities, and receiving real-time notifications.



- To implement a backend system that processes reminders, synchronizes patient-caregiver data, and triggers emergency workflows.
- To store patient information, activity logs, and caregiver records in a centralized database for efficient management.
- To ensure real-time communication with emergency services for immediate assistance during critical situations.
- To create an integrated, scalable, and user-friendly system to improve overall dementia care and patient safety.

IV. ARCHITECTURE

The evolution of automated dementia care monitoring is depicted in this figure. With an emphasis on the suggested Alzheimer's Aid framework, it transitions from conventional manual techniques to integrated, AI-driven systems. According to Pot et al., the timeline identifies significant turning points, including the early reliance on subjective clinical evaluations and paper logs prior to the 2010s, followed by the introduction of simple digital reminders and sensor prototypes in the 2010s, including basic GPS wearables for wandering detection. Regarding this work, the diagram illustrates the basic architecture of Alzheimer's Aid as a scalable platform that integrates sensors to identify odd behaviour in dementia patients in real time.

A central Lifelog Sensor Hub receives granular lifelog data, such as entry/exit patterns and extended periods of inactivity, from adhesive sensors placed throughout nursing homes (e.g., on doors, chairs, and beds for motion and occupancy tracking). In order to provide thorough coverage of daily activities without intrusive monitoring, this hub combines inputs from wearable technology such as smartwatches (for heart rate, falls, and GPS-based wandering alerts) and environmental Internet of Things nodes (e.g., door sensors and motion detectors).

Data flows seamlessly to AWS-hosted management servers for secure storage and processing, where machine learning models (e.g., recurrent neural networks for sequential pattern recognition) analyze lifelogs against personalized baselines to detect anomalies such as irregular sleep cycles, medication non-adherence, or agitation spikes. Detected abnormalities trigger immediate notifications through the integrated smartphone application. This app is available to doctors and caregivers. It shows user-friendly dashboards with visualizations, such as anomaly timelines, risk scores, and intervention recommendations. This system improves the app's main features. For example, cognitive stimulation adjusts based on detected cognitive dips. Medication reminders increase when there are adherence issues. Safety protocols trigger geofencing alerts.

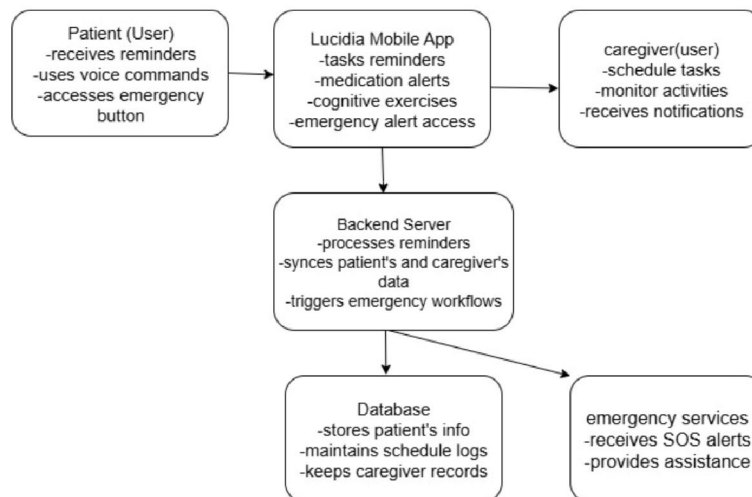


Fig 2. Proposed System Architecture



V. DATA FLOW

The proposed system follows a structured data flow to ensure seamless interaction between the patient, caregiver, mobile application, backend server, and emergency services.

User Input (Patient Side):

The patient interacts with the mobile application through voice commands, task interactions, or by triggering the emergency (SOS) button. Inputs include task completion status, voice requests, and emergency alerts.

Mobile Application Processing:

The mobile app processes user inputs and generates reminders, medication alerts, and cognitive exercise prompts. It forwards relevant data to the backend server for further processing.

Caregiver Interaction:

Caregivers input schedules, assign tasks, and monitor patient activities through their interface. Notifications and updates are received from the system in real time.

Backend Server Processing:

The backend server acts as the central controller, processing reminders, synchronizing patient and caregiver data, and managing workflows. It also detects emergency triggers and initiates appropriate actions.

Database Storage:

All data, including patient information, schedules, activity logs, and caregiver records, are stored in a centralized database for consistency and future retrieval.

Emergency Handling:

In case of an SOS trigger, the backend server sends alerts to both caregivers and emergency services, ensuring immediate response and assistance.

Feedback Loop:

Updates and notifications are continuously sent back to the patient and caregiver interfaces, ensuring real-time synchronization and system reliability.

VI. METHODOLOGY

The proposed system adopts a client-server architecture to provide an integrated solution for dementia care. A mobile application is developed for patients and caregivers, enabling features such as task reminders, medication alerts, cognitive exercises, voice commands, and an SOS emergency function. The design ensures scalability, real-time communication, and secure data handling. Caregivers can schedule tasks and monitor patient activities through a dedicated interface. The backend server processes user inputs, synchronizes data between patients and caregivers, and manages emergency workflows. A centralized database stores patient information, schedules, and activity logs for efficient retrieval. Testing includes functional testing, usability testing, and performance evaluation. In emergency situations, alerts are sent to caregivers and emergency services in real time. The system is tested for functionality, usability, and reliability to ensure effective performance and improved patient care.

VII. EVALUATION METRICS

The performance of the proposed dementia care system is evaluated using multiple metrics to ensure effectiveness, reliability, and usability.

System accuracy is measured by evaluating the correctness of reminders, alerts, and task execution.

Response time assesses how quickly the system processes user inputs and triggers notifications or emergency alerts.

Reliability is evaluated based on system uptime and consistency in delivering services without failure.

Usability is measured through user feedback from patients and caregivers, focusing on ease of use and accessibility.

Emergency response efficiency is analyzed by measuring the time taken to notify caregivers and services after an SOS trigger.



Additionally, **data consistency and synchronization** between patient and caregiver interfaces are assessed to ensure seamless operation.

VIII. FEASIBILITY & SCOPE

The proposed dementia care system is technically feasible as it leverages existing mobile technologies, backend frameworks, and database systems for implementation. Features such as task reminders, notifications, and SOS alerts can be efficiently developed using standard mobile development tools and APIs. The use of a client-server architecture ensures scalability and real-time communication between patients and caregivers. Economically, the system is cost-effective as it can be deployed using widely available platforms without requiring expensive hardware. Operational feasibility is ensured through a user-friendly interface designed specifically for dementia patients and caregivers, minimizing complexity. Additionally, the system is practical to implement as it builds on existing technologies like GPS, notifications, and cloud storage, ensuring reliability and ease of integration.

Application Domain:

The system is designed as a mobile health (mHealth) application aimed at assisting dementia patients in daily activities and improving caregiver support through automation and real-time monitoring.

End Users:

Dementia Patients: Individuals who require assistance with daily tasks, medication reminders, and emergency support.

Caregivers & Family Members: Users responsible for monitoring patients, scheduling tasks, and responding to alerts.

Healthcare Providers (Optional Extension): Professionals who may use patient data for better care management and decision making.

IX. RISKS

Technical Risks

Sensor and Alert Failure (High Priority): Malfunction of sensors, GPS, or notification systems may lead to missed alerts or inaccurate monitoring of patient activities.

System Response Delay (High Priority): Delays in processing data or sending notifications may reduce the effectiveness of emergency alerts and real-time assistance.

Data Synchronization Issues (Medium Priority): Inconsistent data between patient and caregiver interfaces may lead to confusion or incorrect task tracking.

Operational & Ethical Risks

Missed or Incorrect Alerts (High Priority): Failure to trigger reminders or emergency alerts can put patient safety at risk and reduce trust in the system.

Privacy and Data Security Risks (High Priority): Sensitive patient data may be exposed to unauthorized access if proper security measures are not implemented.

Schedule & Resource Risks

Development Delays (Medium Priority): Integration of multiple components such as mobile app, backend, and database may increase development time.

Dependency on Internet Connectivity (Medium Priority): The system relies on network availability for real-time updates and emergency communication, which may affect performance in low connectivity areas.

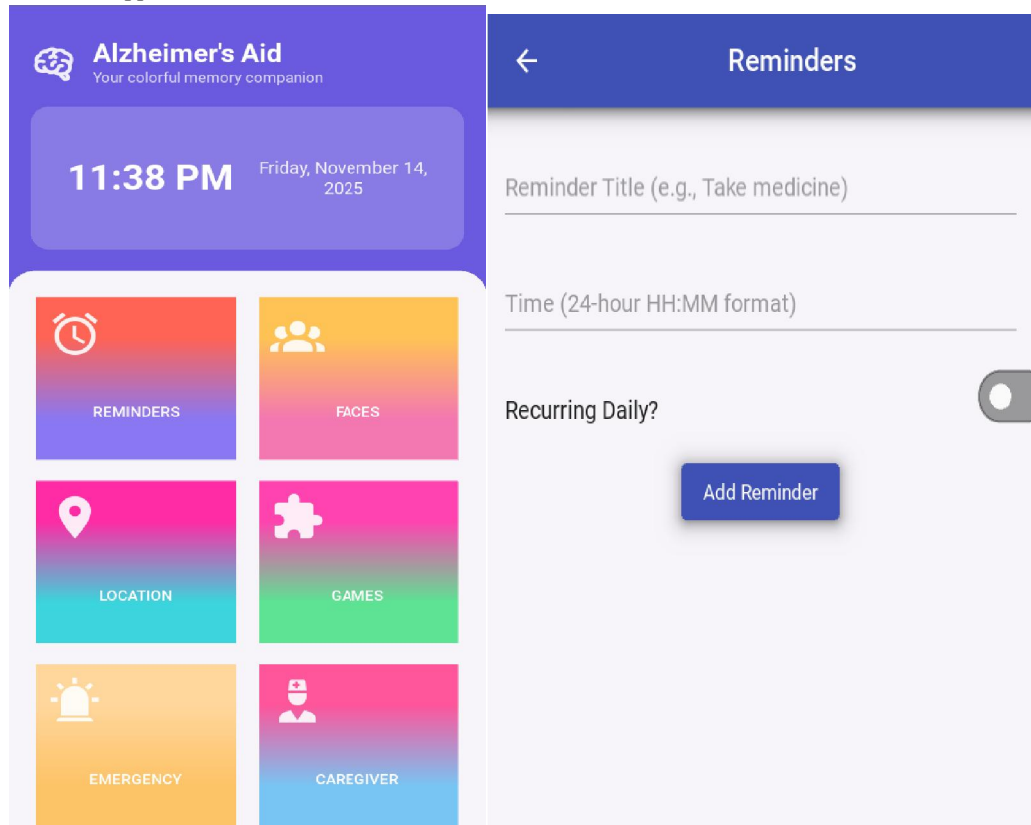
X. RESULTS

The proposed dementia care system was successfully developed and tested, demonstrating effective performance in assisting patients and caregivers. The system accurately delivered task reminders and medication alerts, ensuring improved daily routine management for patients. Real-time synchronization between patient and caregiver interfaces



enabled efficient monitoring and timely updates. The SOS emergency feature functioned reliably, sending instant alerts to caregivers and facilitating quick response in critical situations.

Usability testing indicated that the application is user-friendly and accessible, even for elderly users with limited technical knowledge. The system showed low response time and consistent performance during testing, ensuring reliability. Additionally, data storage and retrieval from the centralized database were efficient and accurate. Overall, the system improved communication, reduced caregiver workload, and enhanced patient safety, demonstrating its effectiveness as a supportive dementia care solution.



XI. CONCLUSION & FUTURE WORK

This study uses mobile health and machine learning to develop a dependable, adaptable tool to enhance dementia care oversight. It consists of sophisticated data synthesis and adaptive cognitive frameworks. In landmark case studies, it achieves mean absolute errors in activity-level measurement below 7%, helps caregivers manage adherence and well-being, and provides real-time integration with care protocols for visualization. Despite these successes, efforts continue to improve workflow automation, generalization, barrier reduction, measuring partial adherence, and user integration and expansion. Future research should focus on the following: -

- Expanding and diversifying annotated datasets, including multi-modal sensing and cross-cohort and cross-cultural data.
- Developing stronger synthesis and multi-sensor methods to handle variable inputs and obstacles.
- Investigating semi-supervised or unsupervised approaches to lessen manual labeling needs.
- Creating smooth, intuitive interfaces and APIs for industry use and home deployment.



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