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AI-BASED DEMENTIA CAREGIVER SUPPORT SYSTEM

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Abstract

Dementia is a progressive condition that affects memory, thinking, communication, behaviour, and the ability to perform everyday activities. Because the need for supervision increases as dementia progresses, family members and other informal caregivers often face a substantial workload. An AI-based dementia caregiver support system can assist caregivers by combining reminders, routine monitoring, safety alerts, conversational assistance, and summarized care information in a single platform. This paper proposes a conceptual system that uses artificial intelligence together with mobile or web interfaces, optional wearable and smart-home sensors, and secure cloud or local data storage. The proposed system can maintain a personalized care profile, schedule medication and daily activities, detect deviations from established routines, support location-based safety notifications, and provide caregiver dashboards for reviewing important events. Machine-learning components can be used for anomaly detection and pattern analysis, while natural-language processing can support simple communication and question answering. Importantly, the system is designed as a caregiver-support tool rather than a replacement for doctors, nurses, or family supervision. The design therefore emphasizes human oversight, explainable alerts, privacy, consent, data minimization, and safe escalation of potentially serious events. The expected outcome is a practical and scalable digital support framework that can reduce caregiver burden, improve awareness of daily routines, and strengthen safety without encouraging over-reliance on automated decisions. Future development can evaluate the system through usability studies, alert-accuracy testing, longitudinal monitoring, and caregiver feedback.

Keywords: artificial intelligence, caregiver support, dementia, health monitoring, safety alerts

I. Introduction

Dementia is a syndrome associated with deterioration in memory, thinking, behaviour, and the ability to perform everyday activities. The World Health Organization reports that 57 million people were living with dementia worldwide in 2021 and that nearly 10 million new cases occur each year. Alzheimer disease is the most common form of dementia and may account for approximately 60-70% of cases [1]. The condition affects not only the person living with dementia but also family members, professional carers, and wider health and social systems.

As dementia progresses, people may require increasing assistance with medication, meals, appointments, communication, mobility, and personal safety. Problems such as getting lost, forgetting tasks, medication errors, sleep changes, or unexpected behavioural changes can create difficult situations for caregivers. Technology can support independence and safety, but it must be used together with regular human care and appropriate professional guidance [2].

Artificial intelligence (AI) provides an opportunity to build systems that can learn patterns from routine data, identify unusual events, summarize information, and provide timely notifications. The National Institute on Aging has supported research into technology-based dementia

assessment, monitoring, sensing systems, electronic records, and robotic applications, while emphasizing effectiveness, usability, cost, and unintended consequences [3].

II. Problem Statement

Traditional caregiving often depends on continuous observation, memory, phone communication, and manual record keeping. A single caregiver may have to remember medication schedules, appointments, daily routines, safety concerns, and changes in behaviour. When several responsibilities occur simultaneously, important events may be missed. The proposed problem is therefore to design an AI-enabled caregiver support system that can organize routine care information, monitor selected safety signals, detect deviations from normal patterns, and communicate prioritized alerts to caregivers.

The system should not attempt to diagnose dementia or make autonomous medical decisions. Instead, it should identify situations that deserve caregiver attention and present understandable information that can support a human decision.

III. Objectives

- To develop a centralized digital platform for dementia caregiver support.
- To provide medication, appointment, hydration, meal, and daily-routine reminders.
- To monitor selected activity and safety signals using smartphones, wearables, or smart-home devices when available.
- To use AI-based pattern analysis to identify unusual deviations from an individual's normal routine.
- To generate prioritized alerts for events such as missed medication, unusual inactivity, or unexpected location changes.
- To provide a simple caregiver dashboard containing recent alerts, routine summaries, and care notes.
- To protect personal information through consent, access control, secure storage, and data minimization.

IV. Proposed System

The proposed AI Dementia Caregiver Support System consists of five major layers: user interface, data acquisition, intelligence and analytics, alert management, and secure storage. The person living with dementia and the caregiver interact through a mobile or web application. Optional sensors can supply activity, location, heart-rate, sleep, or environmental information. The AI layer analyzes selected data and compares current observations with the person's established baseline. When a significant deviation is identified, the alert engine sends a notification to the designated caregiver.

The system can maintain a personal care profile containing preferred routines, medication schedules, emergency contacts, safe locations, and caregiver permissions. A baseline is created from normal observations rather than from a generic assumption about all people with dementia. This personalization is important because dementia symptoms and daily patterns differ from person to person [1].

V. System Architecture

A. Data Acquisition Layer: Data may be entered manually by caregivers or collected from smartphones, wearable devices, medication reminders, GPS/location services, and smart-home sensors. Only necessary data should be collected.

B. Data Processing Layer: The system cleans timestamps, removes duplicate or invalid observations, and converts raw events into meaningful features such as activity duration, medication adherence, sleep duration, and location transitions.

C. AI and Analytics Layer: Machine-learning models can learn normal patterns and detect anomalies. Natural-language processing can support conversational reminders and simple caregiver queries. Rule-based logic can be used for deterministic events such as a scheduled medicine being marked as missed.

D. Alert and Escalation Layer: Alerts are classified by severity. Low-priority events may appear in the dashboard, while higher-priority safety events can trigger immediate notifications to an authorized caregiver. The system should avoid excessive alerts by using thresholds, repeated-event confirmation, and caregiver-configurable preferences.

E. User Interface Layer: The caregiver dashboard should display today's routine, medication status, recent alerts, location status when enabled, and a short daily summary. The interface for the person with dementia should remain simple, readable, and low in cognitive complexity.

VI. AI Modules

1) Routine Anomaly Detection: The model learns a baseline of normal activities, such as typical wake-up time, movement, meal timing, and room transitions. A large deviation can be flagged for caregiver review. The output should be an alert or recommendation, not a diagnosis.

2) Medication Adherence Support: The system records scheduled doses and can provide reminders. If a dose remains unconfirmed after a configurable interval, the caregiver can receive a notification. Technology-based medication aids and reminders are recognized as useful options for people with cognitive impairment [4].

3) Location and Wandering Support: When the user and caregiver have provided consent, location services can help identify unexpected movement outside a defined safe area. GPS technology can reduce the risk associated with wandering, but location tracking is not perfectly accurate and should not be treated as a substitute for supervision [2].

4) Natural-Language Assistant: A conversational interface can answer simple routine questions, read reminders, guide the user through scheduled tasks, or help a caregiver summarize recent notes. Health-related answers should be treated as informational and verified with qualified professionals [2].

5) Daily Care Summary: AI can summarize structured events into a short report for the caregiver, such as completed reminders, missed activities, unusual inactivity, and notable alerts. Summaries should show the underlying event and time so that caregivers can verify the information.

VII. Methodology

The development methodology begins with requirement analysis involving caregivers and, where appropriate, healthcare professionals. The next step is data and interface design, followed by development of the mobile/web interface, database, rule engine, and AI models. Testing should be performed in stages: unit testing, integration testing, usability testing, alert-accuracy evaluation, and controlled pilot evaluation.

For anomaly detection, a simple baseline can be established from historical observations. For each activity feature x, an anomaly score may be calculated from its deviation from the user's baseline mean μ and standard deviation σ:

$$A = |x - \mu| / (\sigma + \varepsilon) \quad (1)$$

where A is the anomaly score, μ is the baseline mean, σ is the baseline standard deviation, and ε is a small value used to avoid division by zero. A threshold can be selected using validation data. The final alert should also consider context and repeated observations rather than relying on a single measurement.

VIII. Expected Benefits

- Reduced manual effort for routine reminders and record keeping.
- Faster caregiver awareness of selected safety-related events.
- Better organization of medication, appointments, and daily activities.
- Personalized monitoring based on the individual's normal routine.
- Improved communication between the person, caregiver, and care team.
- Potential support for independence while maintaining human supervision.

These benefits are expected rather than clinically proven by this conceptual paper. Actual effectiveness must be established through systematic evaluation. Existing dementia technology research emphasizes the need to test effectiveness, usability, cost-effectiveness, and unintended consequences [3].

IX. Privacy, Ethics, and Safety

Dementia-care systems can process sensitive personal information, including location, health-related observations, routines, and caregiver notes. The proposed system should therefore use informed consent, role-based access, encryption, secure authentication, audit logs, and data minimization. Users should be able to understand what information is collected and why it is collected.

AI outputs must be presented as decision-support information. The system should clearly distinguish observed facts from AI-generated interpretations. High-risk events should be escalated to a human caregiver or qualified professional rather than handled autonomously. This is especially important because AI systems can produce incorrect or misleading information, and the Alzheimer's Association advises that AI should not replace a doctor for health decisions [2].

Technology can also create new risks if it is poorly designed. Excessive alerts may cause alarm fatigue, inaccurate location data may create false alarms, and inaccessible interfaces may increase confusion. Regular human check-ins remain necessary. Technology should support independence and safety without becoming a substitute for compassionate human care [2].

X. Limitations

- The conceptual system does not provide clinical diagnosis or treatment.
- Sensor data may be incomplete, noisy, unavailable, or inaccurate.
- AI performance may vary across individuals and environments.
- Continuous monitoring can create privacy concerns and may require explicit consent.
- Internet, smartphone, battery, or wearable failures can interrupt monitoring.
- False-positive and false-negative alerts are possible and must be evaluated.

XI. Future Scope

Future versions can integrate multimodal sensing, improved personalized anomaly models, multilingual voice interaction, fall detection, caregiver workload estimation, and interoperability with electronic health records where legally and technically appropriate. Research can also investigate edge AI to reduce dependence on continuous cloud connectivity. Explainable AI techniques can show caregivers why an alert was generated. Large-scale pilot studies should compare caregiver workload, usability, alert accuracy, safety outcomes, and user acceptance before real-world deployment.

XII. Conclusion

The AI Dementia Caregiver Support System proposed in this paper is a human-centered framework for assisting caregivers with routine management, safety monitoring, reminders, and information organization. By combining AI-based pattern analysis with rule-based alerts and a caregiver dashboard, the system can potentially reduce routine workload and improve awareness of important events. However, dementia care is complex, and technology cannot replace professional medical care or human supervision. Privacy, consent, usability, accuracy, and safe escalation must therefore be treated as core design requirements. The proposed system provides a foundation for future implementation and evaluation of responsible AI-assisted dementia caregiving.

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