CS491: Senior Design Project I

Project Specification Document

Team ID: T2518

Ahmet Yağız Sarıdoğan	22202072
Ayça Candan Ataç	22203501
Elif Ceren Çelik	22202534
Emine Noor	22201252
Irmak İmdat	22201570

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1. Introduction

Dementia and/or Alzheimer's disease create substantial emotional challenges and practical difficulties that affect both patients and their family members and their caregivers [1]. The diseases affect patients' spatial awareness and navigation abilities and executive control while simultaneously causing memory loss that occurs in specific moments. The symptoms require patients to receive ongoing supervision because they need protection from wandering and forgetfulness and disorientation [2]. The need for patient safety supervision creates a conflict because it both protects the patient and infringes on their independence and dignity. The need for ongoing supervision of patients leads to increased anxiety and burnout among their caregivers [3].

ReMind introduces a comprehensive mobile health assistant ecosystem to decrease the pressure on caregivers and patients with location and reminder services, while analyzing the mood of the patient to take measures against cognitive fluctuation. The system provides a safety net by using wearable smartwatch data, caregiver and patient dashboards while being a privacy-based application, protecting the sensitive health and location data of the patient. The application aims to provide a helpful tool for patients to maintain their daily routines safely, without feeling overwhelmed or pressured, while keeping caregivers informed and reassured.

1.1 Description

This project offers a multi-dimensional mobile assistant platform to provide an environment that encourages individuals with Alzheimer's or other forms of dementia to remain independent and maintain their dignity, while minimizing anxiety and workload for caregivers. The mobile application offers different interfaces to two user roles: patients and caregivers.

ReMind has three main elements of functionality: featuring intelligent safety monitoring, daily routine assistance and cognitive support functions.

The application will include a map where people can designate up to three "safe zones". Locations of patients will not actively be tracked or shared with the caregivers, geofencing on OS level will be used and active location tracking and sharing will only become available if the patient leaves the safe zone, alarming the geofencing mechanism. The caregiver will be notified in various different scenarios such as abnormal mood detection or movement outside of the safe zone. When the patient is out of the designated safe zone, the application will guide the patient back to the safe zone with a map and simple, easily understandable instructions.

ReMind will also serve as a cognitive aid by sending the patient reminders for medications and daily routine activities. The patient will then be able to interact with the reminder through options including "taken," "skipped," and "snooze." Caregivers will then be able to see a record of whether the patient completed each activity. Additionally, the patient application will contain a suite of memory games that are designed to be calming and non-competitive. They do not display success to the patient based on performance, nor do they include time limits. Instead, they focus on keeping the patient engaged and stimulated cognitively.

In addition to these safety and daily routine features, the patient application will track the patient's mood throughout the day through a "Mood Check-in" flow. The Mood Check-in is designed to be unobtrusive and take less than 10-15 seconds. It will ask the patient a few simple questions and/or ask the patient to select images that are later used to interpret their mood. An on-device MoodAI module which is personalized and fine-tuned with the data of the patient aims to detect cognitive fluctuations and confusion. The lightweight AI module uses learned behavioral patterns of the patient such as step counts, level of interaction with their phone, game performance, image choices and uses these data to calculate an anomaly score. The results will be more accurate since the comparisons will be made with the patient's own patterns instead of the average activity of other people.

One of the innovative aspects of this system is its ability to collect data from wearable devices (smart watches) to track basic health metrics such as heart rate and step count. While this system will not be used for medical purposes such as diagnosis, it will be able to detect when the patient is experiencing some level of distress or confusion. The health metrics obtained from wearable devices will be used to alert the caregiver for urgent medical conditions and be provided to MoodAI as patient data.

Thus the caregiver is alerted in various conditions such as the patient leaving the safe zone, having a possible medical emergency or experiencing abnormal mood swings or distress. However, this system will have built in features to prevent what is known as "alert fatigue," where the caregiver receives too many notifications. In order to create a balance between protecting the patient and reducing anxiety for the caregiver, notifications will only be sent to the caregiver in urgent matters. All notifications/alerts will be evidence-based and will include important required information such as the reasoning and timestamp of the alert.

The system is architected with a privacy-first principle. To protect sensitive health and location data, processing is performed on-device (Edge Computing) wherever possible [4]. Only essential summaries are transmitted to the server, rather than raw behavioral and health logs. All data storage and transformation is encrypted, and the architecture ensures that caregivers have transparency and control to view alerts, manage safe zones, and understand the logic behind specific warnings directly through the mobile interface. Data will be encrypted with AES-256 while it is at rest, and TLS 1.3 while it is in transit. Thus the sensitive data of the patient will be protected at all times.

1.2 High Level System Architecture & Components of Proposed Solution

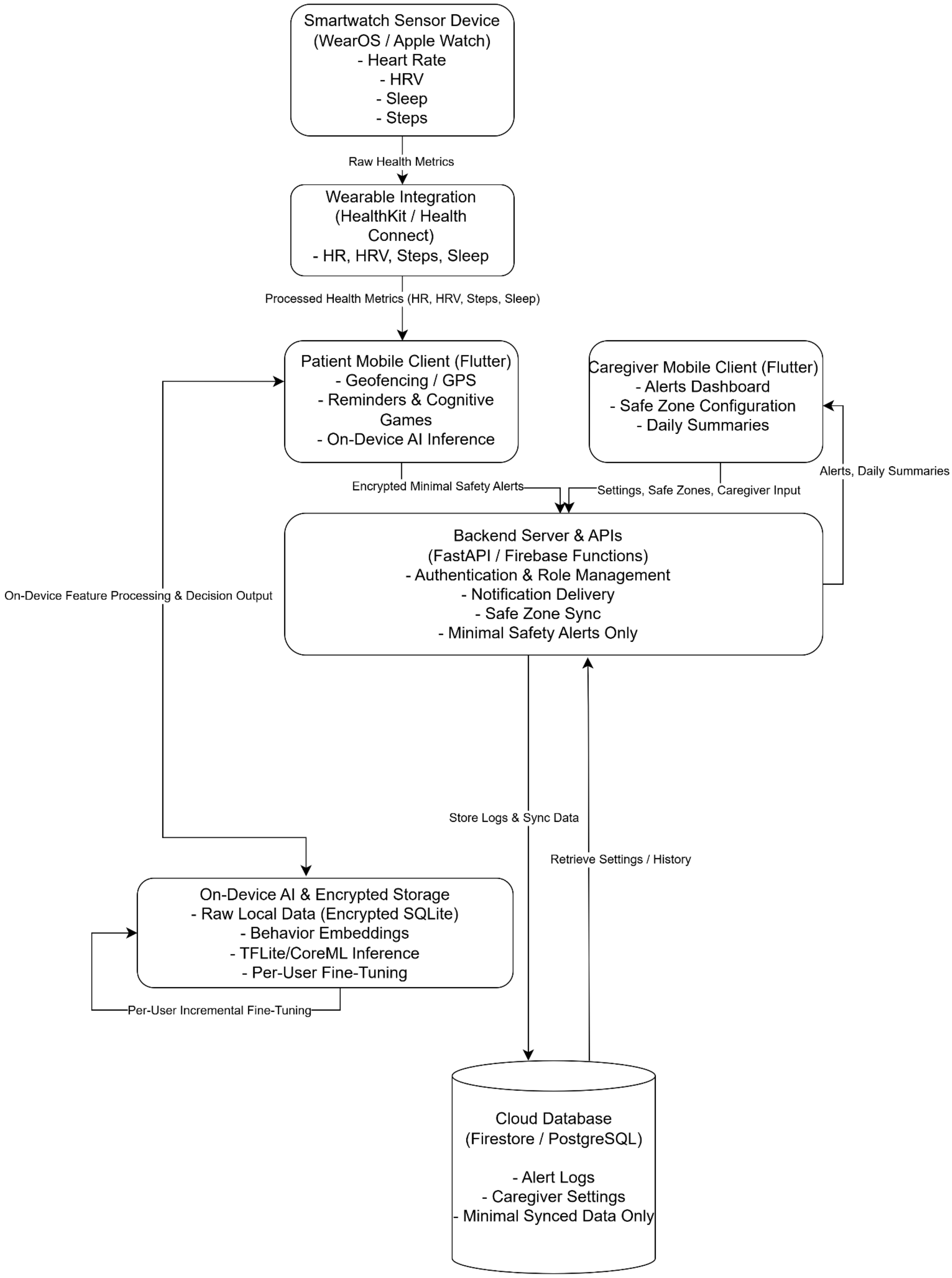

Figure 1: High Level System Architecture Diagram

1.3 Constraints

There are several constraints that shape the design and architecture of the application.

1.3.1. Implementation Constraints

- **Wearable Ecosystem:** The system will obtain health data such as heart rate and step count from Android (WearOS) and iOS (WatchOS) smartwatches by using their health APIs, such as Google Health Connect for Android [5].
- **Battery Optimization:** Smartwatch data retrieval and GPS tracking intervals must be tuned to minimize battery usage on both devices.
- **On-Device Model Limitations:** The MoodAI module must be lightweight to run on mobile devices, limiting the model to optimized formats such as LiteRT [6].
- **Cross-Platform Compatibility:** The app must run on both patient and caregiver devices, so a cross-platform framework such as Flutter is required.

1.3.2. Economic Constraints

- **Hardware Availability:** The patient must own a compatible smartwatch to experience the benefits of the full system, thus the application should support a phone-only mode.
- **API Costs:** Using outsourced mapping and geofencing services (e.g., Google Maps Platform) creates API costs, thus the number of API calls must be minimized.
- **Server and Storage Costs:** While the privacy-first approach decreases the storage of data, the encrypted user history, settings and logs must be stored in a cloud database, which adds to the budget constraints on the project.

1.3.3. Ethical Constraints

- **Autonomy vs. Surveillance:** The system must balance the caregiver's need for information with the patient's right to privacy and autonomy with principles such as sharing patient location only when the patient is outside of the safe zone.
- **Data Consent:** Consent mechanisms must state the potential data usage and permissions in very clear, simple statements since patients with dementia might experience difficulties while understanding the detailed permission requests [7].
- **False Positives:** MoodAI works under the constraint of minimizing false positives to decrease unnecessary panic. If the decision outputs of the model cause an alert, the alert will be provided with context.

1.4 Professional and Ethical Issues

Design of Assistive Technology (AT) for people with cognitive impairment (Alzheimers/Dementia), is directly impacted by several professional and ethical considerations. The first of these is the potential to compromise patients' rights to maintain their autonomy, through the constant monitoring of a person's location and physiological status. The constant monitoring of the person's location and physiological status, may limit the person's ability to experience dignity and privacy. A solution to this "dilemma of surveillance" will be developed into the AT application using "Privacy by Design." Therefore, the caregiver will not receive continuous updates of the individual's location; rather, the caregiver will receive the update only when the individual violates one of the predetermined safety boundaries (e.g., leaves a predetermined "safe zone," exhibits physiological signs of distress). This will ensure the preservation of the individual's dignity and allow the caregiver to respect the individual's desire for independence while establishing an important safety net for the individual.

Another ethical issue in developing this technology is obtaining informed consent from the end-user. Individuals utilizing this technology may not understand the extent of data collection and monitoring utilized within the technology due to potential cognitive limitations. Thus the consent and permissions requests will be stated in very simple and clear statements for the patient to understand.

Reliability and accountability for the algorithms used in the AT applications will also be a major issue. The MoodAI module, which analyzes behavioral patterns to identify emotional distress, is at a high-risk for producing false positives and false negatives. For example, an incorrect decision produced by the MoodAI module may produce panic in the caregiver while failing to alert the caregiver to an actual problem of the patient’s well-being.

To decrease the unnecessary panic caused by false positive alerts, all alerts generated by the AI output will be delivered with context, explaining the reasoning behind alert generation. The application will be treated as a decision support system instead of a complete diagnostic tool. Additionally, data protection regulations such as KVKK and GDPR will be taken into account with edge computing and encryption, making sure no sensitive data is being exposed.

1.5 Standards

Throughout the entirety of the development process of the application, the following international standards will be used to guarantee the reliability, security and inclusivity of the application.

1.5.1 Software Engineering Standards

IEEE 830-1998: This standard will be used for documenting the specifications regarding functional and nonfunctional requirements [9].

IEEE 1016-2009: This standard will be followed when describing the system design [10].

UML 2.5.1: The Unified Modeling Language will be used for all system modeling, including use-case diagrams for user interactions, sequence diagrams for the "Take Me Home" flow, and class diagrams for the backend data models.

1.5.2 Data Security and Privacy Standards

ISO/IEC 27001: The project will follow the international standard for information security management systems (ISMS) to protect the confidentiality, integrity, and availability of sensitive user data [11].

GDPR & KVKK Compliance: The system is designed to fully meet the standards of the General Data Protection Regulation (GDPR) and the Turkish Personal Data Protection Law (KVKK).

Encryption Standards:

- **TLS 1.3:** Used for securing all data in transit between the mobile device, smartwatch, and cloud servers.
- **AES-256:** Used for encrypting all data at rest, including local database storage on the device and remote backups [8].

1.5.3 Accessibility and Usability Standards

WCAG 2.2 (Level AA): The system interface will follow WCAG 2.2 Level AA accessibility standards to provide elderly users and people with disabilities with a comfortable experience through different features such as high contrast design, readable typography and simple navigation system [12].

1.5.4 Mobile Health Data Standards

Google Health Connect & Apple HealthKit: The project will follow the strict data schemas and privacy permissions required by these platforms for accessing vital signs (heart rate, steps). This ensures reliable data retrieval and compliance with app store policies regarding health data.

1.5.5 Coding Standards

Effective Dart, Flutter Best Practices & Secure Backend Patterns: The system will follow Google Effective Dart conventions, Flutter architectural standards and secure backend development methods which include parameterized queries and modular service layers and least-privilege data access. The entire system will benefit from these standards because they create readable code that remains consistent and easy to maintain throughout time.

2. Design Requirements

2.1. Functional Requirements

2.1.1 User and Account Management

FR-UM-01 - User Roles
Two primary user roles shall be supported by the system: **Patient** and **Caregiver**.

FR-UM-02 - Registration and Authentication
The system must allow Patients and Caregivers to perform register, log in and log out functions through email authentication which requires either username and password combination or passwordless email link verification.

FR-UM-03 - Account Verification
The system must verify that the input emails belong to the user, by using a verification link or code, before permitting access to authenticated actions.

FR-UM-04 - Caregiver–Patient Linking
The system must allow Caregiver and Patient profiles to be linked after they both approve the request.

FR-UM-05 - Link Revocation
The system must allow Patients or their Caregivers to terminate an existing Caregiver–Patient link at any given time.

2.1.2 Location Monitoring and Safe Zones

FR-LOC-01 – Safe Zone Definition
The system must allow authorized Caregivers to set up and modify up to three safe zones per patient defined as circular geofences, by offering a map-based interface.

FR-LOC-02 – Safe Zone Limits
The Patient mobile application must monitor the Patient's location by using OS level geofencing until the patient leaves a safe zone, aiming to meet the safety and battery optimization constraints.

FR-LOC-03 – Safe Zone Violation Detection
The system must use geofencing to detect when the patient enters or exits a safe zone.

FR-LOC-04 – Safe Zone Exit Alert
The system must alert the Caregiver when the patient goes outside of a safe zone.

FR-LOC-05 – Current Location Display
The Caregiver interface allows the caregiver to view whether or not the patient is in the safe

zone. If the patient is outside the safe zone, the caregiver is able to view the Patient's exact location.

FR-LOC-06 – Location Monitoring Indicator
The Patient application shall display a clear indicator when location tracking is active.

2.1.3 "Take Me Home" Navigation

FR-NAV-01 – Take Me Home Feature
The Patient application shall provide a "Take Me Home" feature that, when activated, guides the Patient from their current location back to a selected home location using map-based navigation.

FR-NAV-02 – Foreground Requirement
The Take Me Home feature shall be available when the Patient application is in the foreground; background navigation behavior shall comply with the mobile OS's background execution restrictions.

2.1.4 Reminders, Medication, and Daily Routines

FR-REM-01 – Schedule Definition
The system must provide an interface for Patients and Caregivers to create medication schedules and daily routine reminders for each Patient.

FR-REM-02 – Reminder Delivery
The Patient application shall deliver reminders at scheduled times via local notifications and/or in-app prompts.

FR-REM-03 – Reminder Interaction
For each reminder, the Patient application will allow the Patient to respond with one of: **"Done"**, **"Skipped"**, or **"Snoozed"**.

FR-REM-04 – Snooze Behavior
When a reminder is snoozed, the system will reschedule the reminder after a short delay.

FR-REM-05 – Adherence Logging
The system shall log reminder responses (including timestamp and response type) for each Patient.

2.1.5 Mood Check-ins and Cognitive Support

FR-MOOD-01 – Mood Check-in Prompts
The Patient application shall periodically prompt the Patient to complete a Mood Check-in, designed to be completed in approximately 10–15 seconds, using simple questions and/or image selection.

FR-MOOD-02 – Mood Timeline Storage
The system shall store Mood Check-in result logs for each patient that include timestamps and the Patient's responses.

FR-MOOD-03 – Mood Trend Visualization
The Caregiver interface shall allow Caregivers to review mood trends over time (e.g., daily/weekly graphs or summaries) for each Patient.

FR-COG-01 – Cognitive Games Library
The Patient application must offer cognitive and memory games that are calming and non-competitive.

FR-COG-02 – Non-Competitive Design
The cognitive games must explicitly avoid competitive elements such as leaderboards, timers or rankings.

2.1.6 Sensor and Smartwatch Integration

FR-SEN-01 – Smartwatch–Phone Pairing
The system shall allow a Patient's smartwatch application to securely pair with the Patient's mobile application on the same account.

FR-SEN-02 – Supported Wearable Platforms (Initial Scope)
The system shall support integration with at least one smartwatch platform for each mobile OS in scope, such as:

- **iOS**: Apple Watch via HealthKit and watchOS health APIs
- **Android**: Wear OS smartwatch via Health Connect and/or Health Services APIs

FR-SEN-03 – Phone-Only Mode
When a compatible smartwatch is not paired or available, the system shall switch to a phone-only mode that relies on built-in phone sensors and provides a limited but functional feature set. If smartwatch data suddenly becomes unavailable, the Caregiver and Patient must both be notified.

FR-SEN-04 – Periodic Vital and Activity Collection
When a compatible smartwatch is available and paired, the system shall periodically collect basic vital and activity data from platform health APIs, at a sampling interval that is compatible with the privacy and battery constraints.

2.1.7 MoodAI Anomaly Detection and Support Cards

FR-AI-01 – On-Device MoodAI Module
The Patient application shall include an on-device MoodAI module that computes an anomaly score for the Patient's current state using available signals, such as:

- gait speed or activity patterns (where available),
- step counts and movement patterns,
- adherence to reminders and routines,
- mood check-in responses,
- engagement with cognitive games.

FR-AI-02 – Input Adaptation by Mode
The MoodAI module shall adapt its input feature set based on available sensors and data sources (e.g., smartwatch + phone vs. phone-only mode) and must not assume that all signals are always present.

FR-AI-03 – Anomaly Thresholds
The system shall define configurable thresholds or levels for anomaly scores such as normal, moderate, high and the system behavior must adapt according to the score at each level.

FR-AI-04 – Support Card Triggering
When MoodAI detects a moderate anomaly, the system must display a support card on the Patient's phone and act according to the Patient's response to the card.

FR-AI-05 – Support Card Options
Support cards shall offer at least the following response options to the Patient:

- "I'm okay"
- "Alert my caregiver"
- "Take me home"

FR-AI-06 – Escalation of Persistent Anomalies
If a moderate anomaly continues past its established time limits, or if MoodAI detects a high anomaly, the system shall escalate by generating a high-priority alert to the Caregiver.

2.1.8 Alerts and Caregiver Notification Management

FR-ALR-01 – High-Priority Alert Conditions
The system shall generate a high-priority alert to the Caregiver when at least one of the following conditions occurs:

- The Patient exits a configured safe zone.
- MoodAI detects a high anomaly state.

- A moderate anomaly persists beyond the configured duration.
- The Patient generates an alert by selecting "Alert my caregiver" on the support card or SOS on the dashboard.

FR-ALR-02 – Alert Content
Each high-priority alert sent to a Caregiver must at least contain a human-understandable reason for the alert, the Patient's last known location and a timestamp.

FR-ALR-03 – Alert Delivery Channels
The system shall support notifications as the prime and default channel. Additional channels such as SMS or email may be supported depending on implementation and platform.

FR-ALR-04 – Alert History View
The Caregiver interface must provide a history of alerts for each Patient.

FR-ALR-05 – Notification Preferences
Caregivers shall be able to configure notification preferences, including:

- quiet hours,
- preferred alert channels,
- sensitivity levels for MoodAI-generated alerts.

2.1.9 Privacy, Consent, and Data Governance

FR-PRV-01 – Onboarding Consent Flow
During onboarding, the system shall present explicit consent flows that allow Patients to:

- approve linking with Caregivers,
- approve collection and limited sharing of location and health data,
- configure when and how location data is shared with Caregivers.

FR-PRV-02 – Privacy & Data Use Page
The application shall provide a "Privacy & Data Use" page that clearly describes:

- what categories of data are collected,
- how each category is used (e.g., alerts, mood trends, navigation),
- which data is shared with Caregivers and under what conditions.

FR-PRV-03 – Minimal Server Storage
The system shall store only essential summary events on the server for caregiver awareness, while raw sensor data and detailed behavior logs remain on the device whenever possible.

FR-PRV-04 – Monitoring Awareness
The Patient application must display clear visual indicators when monitoring and data collection related to location and health signals are active.

FR-PRV-05 – Account and Data Deletion
Patients must be able to request deletion of their account and associated cloud-stored data, subject to legal retention requirements.

FR-PRV-06 – Data Export for Clinical Use
The system shall allow Patients and Caregivers to export a summary of relevant data for a selected time range, including at least:

- alert history,
- reminder adherence,
- mood trends, in a human-readable format such as PDF suitable for sharing with clinicians.

2.2. Non-Functional Requirements

2.2.1. Usability

The system needs to be user-friendly because it serves patients with Alzheimer's disease and other dementia types along with their caregivers who need immediate access to clear and accurate information. The system needs an easy-to-use interface which lets users find all features by using basic navigation that reduces mental work.

- Ease of Navigation
  - The patient application needs to show a clean interface which uses big buttons and strong visual contrast and keeps text usage to a minimum.
  - The system requires users to access Take Me Home, reminders and mood check-ins through an always-visible interface which eliminates the need for complex menu navigation.
  - The caregiver interface should display information based on priority levels which starts with alerts followed by daily summaries.

- Accessibility
  - The system needs to follow WCAG 2.2 Level AA accessibility standards to support users with visual, motor and cognitive disabilities.

- The system needs to avoid using color alone for indication because it will use additional text and symbolic indicators instead.
- The system designers need to create mood check-in and game interfaces which prevent user confusion and frustration through basic choices and absence of time limits and failure states.

- Interaction Simplicity
  - Users can verify their responses to reminders by tapping once which gives them instant confirmation of their actions.

- Onboarding & Guidance
  - Both patient and caregiver apps must include short onboarding flows explaining controls in plain language.
  - Tooltips and micro-tutorials will clarify safe zone setup, alert logic, and device-sensor permissions. The patient and caregiver applications need to start with basic sections which describe their controls using easy-to-understand terminology.
  - The system provides tooltips and micro-tutorials which assist users in learning about safe zone setup and alert system operation and device permission control.

2.2.2. Reliability

The system needs to operate reliably under real-world conditions which include network fluctuations, battery limitations and sensor signal interruptions.

- System Continuity
  - The system operates background tasks for location tracking, safe zone monitoring and vital signal collection without requiring user intervention.
  - When watch data is unavailable, the system falls back to phone sensors.
- Fail-Safe Alerting
  - The system needs to deliver safety alerts because it requires network connectivity to function properly. The system stores outgoing notifications in a queue until delivery success is achieved.
  - MoodAI operates as a local anomaly detection system which functions independently from any network requirements.
- Data Integrity
  - The system requires log encryption before starting reliable synchronization when network connectivity becomes available.
  - The system needs exponential backoff for retry attempts to stop any event loss from occurring.
- Resilience
  - The system needs to return to its safe operational state following crashes while maintaining all current alerts and system logs.

2.2.3. Performance

The system requires optimal performance because it determines user safety and their willingness to trust the system. The system needs to optimize its use of sensors, data processing and alert transmission for better performance.

- Latency Requirements
    - The system needs to start generating and sending safe zone breach alerts right away through a process that should take no longer than five seconds when it detects any breach.
    - The system needs to perform MoodAI anomaly inference within one second to generate real-time support cards.
- Sensor Efficiency
    - The system needs to adjust its background polling rates for GPS, heart rate and movement data based on user behavior.
    - The system needs to perform low-frequency sampling during normal activities to save battery power but switch to high-frequency sampling when it detects anomalies or when the user leaves the safe zone.
- Server Performance
    - The caregiver dashboard needs to show summary information right away through a 3–5 second display that shows data from previous months.

2.2.4. Supportability

The system requires operational maintenance to enable developers to perform maintenance work and resolve problems without disrupting user access.

- Logging & Diagnostics
    - The system needs to store detailed local logs which include sensor data, alert generation conditions and geofence entry events in protected storage.
    - The system provides developers with access to anonymous telemetry data to solve problems that affect battery life and cause abnormal app crashes and synchronization problems.
- Error Transparency
    - The system needs to deliver complete system problem details to users through basic notifications which provide easy-to-follow repair procedures.
    - The system needs an alert system to inform caregivers about patients who require vital device permissions.
- Modular Architecture
    - The system requires separate feature modules which allow developers to make separate updates and bug fixes.

2.2.5. Scalability

The system architecture needs to handle expanding user numbers, rising sensor data amounts and new AI functionality additions.

- User Scalability
  - The system should support thousands of caregiver–patient pairs with no degradation in alert delivery speed or dashboard responsiveness.
  - Each caregiver may manage multiple patients without performance loss.
- Data Scalability
  - The cloud storage system needs to handle extended log retention periods which include multiple months of patient data.
  - The system needs caregivers to access previous data through fast retrieval methods.
- Compute Scalability
  - The backend services need to automatically scale their resources to handle peak alert processing demands which occur when GPS outages affect multiple devices simultaneously.
  - The system needs direct device execution of MoodAI fine-tuning and anomaly detection operations to minimize server processing needs.
- Feature Growth
  - The system design needs to support future additions of new cognitive games and advanced anomaly models through non-disruptive architectural changes.

3. Feasibility Discussions

3.1. Market & Competitive Analysis

The development of dementia and Alzheimer's care technology has experienced rapid expansion during the last ten years because of rising worldwide requirements. The worldwide dementia population exceeds 55 million people at present and scientists predict this number will increase to 78 million during the next decade. The expanding requirement for dementia care has established a market system which focuses on protecting patients and enabling distant caregiving and cognitive assistance [1]. The current market solutions operate independently because they concentrate on individual features such as tracking and reminders and cognitive exercises instead of creating an integrated system. Our project fills the existing void in this market segment.

3.1.1 Competitive Landscape Overview

Existing products cluster around two categories:

1. Location Tracking & Geofencing Solutions

   Examples: AngelSense, Safe365, Life360

   Strengths:

   - Real-time GPS tracking;
   - Geofence alerts;
   - Simple mobile interface for families.

   Limitations with Respect to Our Context:

   - Lack of contextual alerts—send notifications even when risk is low, causing alert fatigue.
   - No integration with mood data, routines, or physiological signals.
   - No smartwatch-based support flow or early anomaly detection.

2. Cognitive Support & Reminders

   Examples: Medisafe, Dementia Clock, MindMate, Lumosity

   Strengths:

   - Medication reminders;
   - Memory games;
   - Mood tracking in isolated form.

   Limitations:

   - No behavioral AI that adjusts reminders based on consistency.
   - No linkage between mood, physiological signals, and movement patterns.
   - Not integrated with caregiver oversight or safety systems.

3.1.2 Gap Analysis

Across major products, there is no unified platform that brings together:

- Real-time safety monitoring
- Smartwatch-based physiological tracking
- Context-aware anomaly detection (MoodAI)
- Autonomous risk reduction (support cards, Take Me Home)
- Caregiver dashboards with actionable summaries

Current solutions treat safety, cognitive support, and health monitoring as separate problems. Our project uniquely combines these domains into one ecosystem designed specifically for dementia contexts. This positioning demonstrates the feasibility of differentiating our system from current offerings due to its multi-layered, cross-device intelligence and human-centered design.

3.1.3 Our Value Proposition Compared to Market Competitors

Capability	Existing Tools	Our System
Location tracking	Available, often continuous & intrusive	Event-based, privacy-first alerts
Geofencing	Yes, but simplistic	Multi-zone adaptive safe areas
Wearable vitals	Yes, but not contextualized	AI-combined with routines & mood
Cognitive support	Partially available	Integrated mood + task + game ecosystem
Caregiver dashboard	Basic	Unified logs, analytics, alert reasons
On-device ML	Rare	Privacy-first MoodAI
Alert relevance	Often too frequent	Evidence-based combined signals

Table 1: Capabilities compared across existing tools and ReMind

3.2. Academic Analysis

The project receives support from academic research which combines knowledge about geriatrics with cognitive science, mobile computing and human–AI interaction.

3.2.1 Healthcare Motivation

Research studies demonstrate that dementia patients and their caregivers experience various difficulties:

- The condition of wandering and disorientation affects 60% of patients who have Alzheimer's disease [13].
- The process of caring for others leads to caregiver burnout which results in emotional exhaustion, sleep disturbances and decreased patient care quality [14].
- The practice of excessive monitoring leads to decreased patient freedom and loss of dignity [15].

Academic research demonstrates that assistive systems need to achieve safety through autonomous system design which our privacy-first and event-driven alert system implements [15].

3.2.2 Importance of Proactive, Not Reactive, Systems

The present monitoring systems produce alerts only after incidents happen which includes patient falls and safe zone departures. Research studies have proven that monitoring systems have some fundamental characteristics:

- The early detection of behavioral changes which have not reached emergency levels enables people to stop dangerous situations from occurring [16].
- Research shows that patient health monitoring through multiple signals which combine heart rate variability data with movement tracking and adherence tracking enables better detection of cognitive decline patterns [17].
- Users achieve privacy protection through device calculations which also speed up response times [18, 19].

The MoodAI system uses edge cognitive monitoring techniques which run lightweight models for early risk assessments without requiring cloud-based processing.

3.2.3 Digital Therapeutics & Cognitive Support

Research studies show that mobile technology helps dementia patients improve their cognitive functions and reduce their anxiety symptoms [20, 21]:

- Touch-based memory games help patients stay engaged because they prevent feelings of frustration from occurring [20, 22].
- Short mood assessment sessions produce the best results for elderly people because they do not need to write long journal entries [22].
- The combination of medication and hydration reminders within structured routines enhances both patient safety and self-reliance [23].

The application includes all three features because of its minimal cognitive load design approach.

3.2.4 Human–Computer Interaction (HCI) Considerations

Research studies about elderly technology adoption have demonstrated that:

- Users will leave systems whenever they need to navigate through difficult user interfaces [24].
- Soft interventions that use nudges achieve superior results than the conventional approach of using alarm systems [25].
- Patients show better responses to supportive statements which include "Would you like to rest?" instead of direct commands [26].

The application features support cards, stress-free games and gentle reminders based on these research findings.

3.2.5 Ethical and Privacy Alignment

- Research studies show that edge computing systems protect health information and location data from unauthorized access [27].
- Research shows that patients need to give direct consent when their mental ability to make decisions becomes impaired [28].
- Users require basic visual signals to track their activities because these signals help them avoid feelings of being watched [25, 29].

The system design follows these recommendations through its use of encrypted on-device logs and consent flows and visual monitoring indicators.

3.2.6 Technological Feasibility

The current state of technology allows for the following based on academic research and industrial developments:

- WearOS and Apple Watch devices consistently provide HR and HRV and step sensor data which scientists can use for anomaly detection [30].
- Google Health Connect and HealthKit allow users to safely merge their health data through their built-in standardized data formats [31].
- The Flutter framework enables developers to build high-performance applications which run across different platforms through methods that support long-term development [32].
- The combination of TFLite and CoreML allows small models to run efficiently on devices through on-device systems [33].

The basic technical elements have proven successful in scientific research and industrial production environments.

5. Glossary

AI: Artificial Intelligence
API: Application Programming Interface
GDPR: General Data Protection Regulation
GPS: Global Positioning System
HCI: Human–Computer Interaction
HR: Heart Rate
HRV: Heart Rate Variability
KVKK: Kişisel Verileri Koruma Kanunu
ML: Machine Learning
UI: User Interface
UX: User Experience
WCAG: Web Content Accessibility Guidelines
Wi-Fi: Wireless Fidelity
ISMS: Information security management systems

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Note: The .drawio source file for the High Level System Architecture Diagram can be found in the following link in case the image appears unclear:
https://drive.google.com/drive/folders/1I8Yx-k4dp75kRruM9d09IaRh1D4h5Udu?usp=drive_link