Intelligent Tracking and Alert System for Dementia Patients

Priyanka Mashetty[1*], Ashwini[2], Abhinav Chapte[3], Abhishek[4], Kaveri Chavan[5]

[1]Professor, Dept of Information Science and Engineering, Guru Nanak Dev Engineering College, Bidar-585403, Karnataka
[2,3,4,5]Dept of Information Science and Engineering, Guru Nanak Dev Engineering College, Bidar-585403, Karnataka
priyanka.mashetty@gmail.com

Abstract

A dedicated healthcare support solution has been developed in this work using an Arduino UNO microcontroller, incorporating geo-fencing capability, automated medication reminders, and continuous health monitoring specifically designed for individuals suffering from dementia. To ensure patient well-being and safety, the proposed system integrates multiple sensing components including pulse rate, body temperature, and MEMS-based fall detection sensors, all of which feed data continuously into the microcontroller for processing and real-time display on an LCD screen. Location tracking is achieved through a GPS module, and whenever critical health parameters breach predefined thresholds or the patient exits the designated safe zone, instant SMS notifications are delivered to the caregiver via a GSM module. A virtual geographic boundary is established using geo-fencing; any violation of this boundary triggers both a buzzer alarm and an automated location alert to the responsible caregiver. The medication reminder subsystem operates on a built-in timer that activates audio-visual signals at prescribed intervals, and prolonged non-compliance automatically escalates to a GSM-based caregiver notification. All sensor data acquisition, processing, communication, and output operations are handled by the Arduino UNO as the central processing unit, with the entire system firmware implemented in Embedded C. The resulting system delivers a dependable, all-in-one solution for remote dementia care through seamless integration of health surveillance, safety enforcement, and medicine adherence management.

Keywords- Dementia, GPS tracking, Alert system, Assisted living, Smart healthcare systems.

1. Introduction

Ensuring the safety and health of elderly individuals, particularly those diagnosed with dementia, has become a growing concern in modern healthcare. Such patients frequently fail to adhere to medication schedules and are prone to wandering beyond safe boundaries, posing serious risks to their well-being. To tackle these challenges, a geo-fencing-enabled smart medication reminder system with integrated health monitoring has been developed on the Arduino UNO platform. The device continuously tracks vital parameters such as heart rate and body temperature while simultaneously monitoring physical movements. Caregivers are instantly notified via GSM text messages whenever the patient crosses a defined geographic limit or when any monitored health parameter deviates beyond an acceptable range. By combining location awareness, health surveillance, and automated medication alerts, this system significantly contributes to enhancing the autonomy and quality of life of dementia patients and the elderly.

2. Related Work

[1] An Arduino-based vehicular control framework that eliminates the need for conventional manual operation was presented in this study. The research introduced two primary control approaches: one involving hand-gesture recognition using an accelerometer mounted on a glove paired with an Arduino Nano and RF transmitter, and another employing an Android smartphone application supporting touch-based and voice command inputs via Bluetooth. Additionally, an autonomous front-facing obstacle detection module was incorporated to enhance safety. Prototype-level experiments validated the feasibility, efficiency, and cost-effectiveness of the integrated control architecture.

[2] Vehicle theft has emerged as a persistent challenge across modern societies, disproportionately impacting owners who lack access to expensive recovery solutions. A self-reliant vehicle tracking solution was engineered in this work, enabling vehicle owners to independently monitor their automobiles without depending on law enforcement. Leveraging a PIC microcontroller as the processing core, the system fuses GPS-based positioning with GSM-based wireless

communication to deliver an affordable, practical anti-theft tracking mechanism.

[3] The rapid proliferation of connected devices under the IoT paradigm has introduced significant complexity into system development, necessitating well-defined design methodologies. This work examined structured design patterns for building scalable and maintainable IoT-based healthcare monitoring platforms. A particular emphasis was placed on the accuracy requirements of patient health data, given the critical nature of clinical decision-making, along with the importance of continuous monitoring, real-time feedback, and early anomaly detection in remote patient care.

[4] Wireless sensor technologies form the foundation of contemporary health informatics, enabling non-invasive remote monitoring of patients at risk of sudden medical emergencies. A patient health monitoring framework targeting elderly individuals was proposed, utilizing heartbeat sensors interfaced with an ESP8266 NodeMCU module connected to a Wi-Fi network. The collected physiological data is relayed to a web server, enabling real-time remote visualization with timestamps, thereby allowing family members and medical staff to monitor patient status without physical presence.

[5] With the accelerating adoption of smart mobile devices in everyday life, there exists a compelling opportunity to extend healthcare reach through mobile-integrated IoT systems. This project aimed to construct a comprehensive health monitoring platform capable of simultaneously tracking body temperature, respiratory rate, cardiac activity, and blood glucose concentration. A Wi-Fi-enabled microcontroller-based IoT node was employed for sensor data acquisition and cloud-based transmission, facilitating continuous and accessible remote patient care.

[6] Building upon the growing penetration of mobile technology in healthcare, an IoT-driven patient monitoring architecture was conceptualized to oversee multiple vital health indicators concurrently. The system captures and transmits critical metrics—including body temperature, respiratory rate, heart rate, and glucose levels—through a Wi-Fi-connected microcontroller. The resulting platform supports proactive healthcare delivery by enabling continuous oversight and timely intervention by medical personnel.

[7] As the healthcare sector increasingly embraces digital transformation, IoT-enabled patient monitoring has emerged as a highly effective approach to improving care continuity. A comprehensive IoT-based Patient Monitoring System (PMS) was designed and implemented, featuring wearable non-invasive biosensors for acquisition of heart rate, blood pressure, body temperature, and SpO2 data. Secure encrypted transmission protocols were employed to protect sensitive patient data during transfer to a centralized cloud repository, while strict authentication mechanisms ensured controlled access for authorized healthcare providers.

[8] To address the limitations of clinic-bound patient observation, an IoT-integrated health monitoring solution was proposed for deployment in both home and clinical environments. Biosensors continuously acquire heart rate, body temperature, blood glucose, and oxygen saturation data, which is analyzed in real time to detect deviations and generate timely alerts. Securely transmitted to a cloud platform, the collected data supports remote visualization and individualized care planning, ultimately improving patient outcomes while reducing healthcare costs.

[9] The expansive growth of IoT-enabled sensing platforms has opened transformative possibilities across numerous application domains, with healthcare standing as a particularly impactful area. A smart monitoring solution targeting diabetic patients was developed, incorporating simultaneous measurement of blood glucose, body temperature, heart rate, and blood oxygen levels. This system aims to support chronic disease management through continuous parameter surveillance and early warning capabilities.

[10] Exploiting the dual-core performance and built-in Wi-Fi capability of the ESP32 microcontroller, an IoT-based health monitoring system was developed for continuous tracking of heart rate, body temperature, and blood oxygen saturation. Measured data is wirelessly relayed to a cloud server and visualized through a real-time web dashboard accessible to caregivers and clinicians. The system is particularly suited for elderly and remote patients who require ongoing health assessment outside of hospital settings.

3. Materials and Methods

The developed system employs the Arduino UNO as its primary computational unit, orchestrating the operation of all integrated hardware modules. Three types of sensors — a pulse rate detector, a body temperature sensor, and a MEMS accelerometer — provide continuous physiological and motion data to the microcontroller. Real-time positional information of the patient is obtained using a GPS receiver, while a GSM communication module is employed to dispatch automated SMS alerts to a designated contact number whenever an abnormal health event is identified.

System status, live sensor values, and alert messages are rendered on a connected LCD display for on-site visibility. A timer-driven medication alert module activates a buzzer and indicator light at pre-configured time intervals to prompt the patient for drug intake. Should the patient fail to acknowledge the reminder within the allowed window, an escalation alert is automatically forwarded to the caregiver through the GSM network.

Geographic safety is enforced through a geo-fencing mechanism that defines a permissible zone around the patient. Any movement beyond this boundary immediately triggers an alert SMS carrying the patient's precise GPS coordinates, empowering the caregiver to respond swiftly. The entire system logic is implemented in Embedded C, resulting in a lightweight, power-efficient, and dependable remote care tool suitable for dementia patients and the elderly.

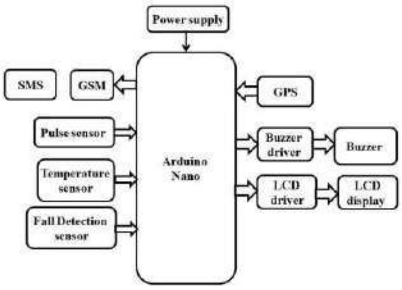

Fig. 3.1: Block Diagram of Smart Pill Reminder with Geo-Fencing and Health Monitoring System

The key hardware components constituting this system include: an adapter-based power supply unit, Arduino Nano microcontroller, heart rate (pulse) detection sensor, body temperature sensing module, MEMS accelerometer for fall detection, LCD display unit, alarm buzzer, GSM communication module, and GPS positioning receiver.

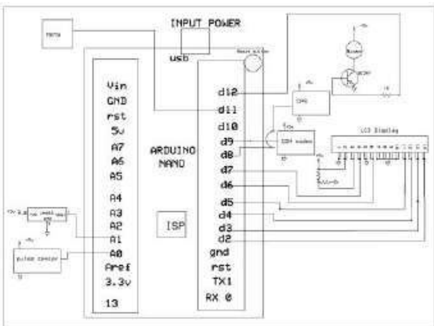

Fig. 3.2: Schematic Diagram of Smart Pill Reminder with Geo-Fencing and Health Monitoring System

3.1 Microcontroller

The Arduino Nano is a compact, feature-rich microcontroller board well-suited for space-constrained embedded projects and rapid prototyping. Developed by Arduino, an open-source hardware and software initiative, this board is built around the ATmega328 SMD chip. It provides 14 digital I/O pins (of which 6 support PWM output), 8 analog input channels, one hardware UART, a 16 MHz crystal oscillator, a mini-USB interface for programming and power, and an on-board reset button.

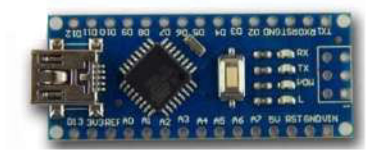

Fig. 3.3: Arduino Nano

3.2 Adapter Power Supply

Commonly referred to as AC/DC adapters, wall adapters, or plug packs, external power supply units convert alternating current from a mains outlet into a regulated DC voltage suitable for powering embedded electronic systems. These adapters supply the required operating voltage to the system without the need for internal power conversion components, and their internal circuit topology closely mirrors that of built-in power supplies found in integrated devices.

Fig. 3.4: Power Adapter

3.3 GSM

The Global System for Mobile Communications (GSM) represents the most widely adopted standard for digital cellular telecommunications worldwide. Mobile devices connect to the nearest available cell tower within the operator's GSM network to establish voice and data communication. GSM serves as the globally recognized benchmark for digital wireless communication, underpinning the reliable SMS alert functionality employed in the proposed system.

3.4 GPS

Originally conceived for military navigation under the name NAVSTAR, the Global Positioning System (GPS) has since revolutionized civilian applications in domains ranging from aviation and maritime navigation to personal tracking. The system operates through a constellation of satellites that broadcast L-band signals encoded with ranging codes — the coarse acquisition (C/A) code available to all users, and the precision P-code reserved for authorized users achieving positional accuracy of approximately 3 meters. The GPS receiver employed in this system provides uninterrupted, all-weather positioning and timing data wherever at least four satellites are within line of sight.

Fig. 3.5: Neo 6 GPS Receiver

3.5 Pulse Sensor

The pulse sensor is an easy-to-integrate, plug-and-play optical heart rate measurement device designed for broad accessibility. It enables developers, students, artists, and athletes to seamlessly incorporate live pulse rate data into their projects. The sensor includes an open-source monitoring application with real-time graphical representation of the heartbeat waveform, making it ideal for embedded health monitoring applications.

Fig. 3.6: Pulse Sensor

3.6 Buzzer

The buzzer used in this system operates on the piezoelectric principle, where a ceramic disc bonded to a metallic plate deforms mechanically when a voltage is applied across its electrodes. Under DC excitation, this deformation is static, while AC voltage causes the diaphragm to oscillate cyclically, producing audible sound waves in the surrounding air. The resulting acoustic signal serves as the primary alert mechanism for medication reminders and emergency notifications.

Fig. 3.7: Buzzer

3.7 LCD Display

Liquid Crystal Display (LCD) modules are among the most frequently interfaced output peripherals in microcontroller-based systems. The 16x2 and 20x2 configurations are standard choices, capable of rendering 16 or 20 alphanumeric characters per line across two rows. Communication with the microcontroller is established via 3 control lines combined with either 4 or 8 data lines, supporting both 4-bit and 8-bit operating modes depending on the application's pin constraints.

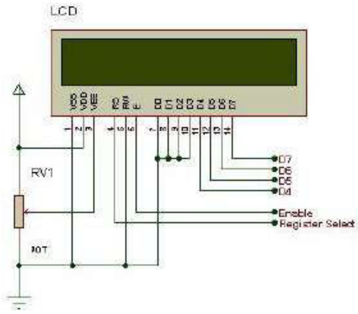

Fig. 3.8: Basic 16x2 Characters LCD

3.8 Temperature Sensor

The NTC (Negative Temperature Coefficient) thermistor module is a cost-effective and miniaturized component whose electrical resistance varies inversely with ambient temperature. It is predominantly used for environmental temperature measurement in embedded systems. The sensitivity threshold is tunable via an onboard potentiometer, and the digital output can be directly interfaced with a microcontroller to detect temperature excursions. This module operates within a measurement range of 20°C to 80°C, and the 4-wire measurement configuration is preferred for highest accuracy as it eliminates the effect of lead resistance.

Fig. 3.9: NTC Thermistor

3.9 Arduino IDE Compiler

The Arduino Integrated Development Environment (IDE) provides the programming interface for writing, compiling, and uploading firmware to Arduino-compatible boards. When using a standalone ATmega328 chip on a breadboard, a bootloader must first be burned onto the microcontroller to enable sketch uploads over USB. It is important to note that not all ATmega328 variants come pre-loaded with a bootloader, and the bootloader itself is a small resident program that facilitates communication between the IDE and the chip during programming.

Fig. 3.10: Bootload the ATmega328

Fig. 3.11: Burn the Bootloader

4. Results and Discusion

The proposed geo-fencing and health monitoring system was successfully assembled and validated using the Arduino UNO platform, with all integrated sensors and communication modules functioning as intended. Throughout testing, the system maintained uninterrupted acquisition of heart rate, body temperature, and motion data through the respective pulse, temperature, and MEMS sensors. All captured readings were rendered accurately on the LCD panel in real time, confirming the reliability of the data acquisition and display pipeline.

The medication alert subsystem demonstrated consistent performance by generating buzzer and LED signals at programmed time intervals. When simulated non-compliance was introduced — i.e., no acknowledgement of the medication prompt within the designated response window — the GSM module successfully dispatched an automated SMS notification to the configured caregiver contact number, validating the escalation logic.

[16:48:27] Pulse: 61 bpm | Temp: 37.6°C | MEMS: 2.14 | GPS: 17.3905,78.4957 ALERT: Movement anomaly: 2.14 ALERT: Geofence breach at (17.3905, 78.4957) [16:48:33] Pulse: 130 bpm | Temp: 35.4°C | MEMS: 1.11 | GPS: 17.3921,78.4867 ALERT: Pulse abnormal: 130 bpm ALERT: Temperature abnormal: 35.4°C ALERT: Geofence breach at (17.3921, 78.4867)

Fig. 6.1: Parameter Readings

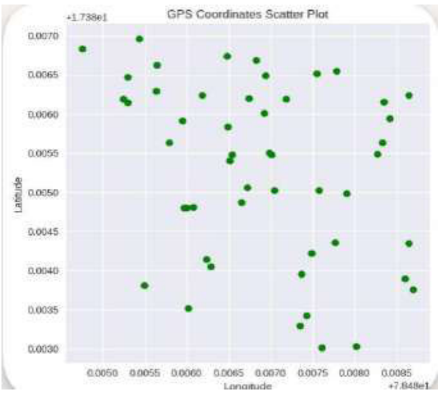

Fig. 6.2: GPS Values for Scatter Plot

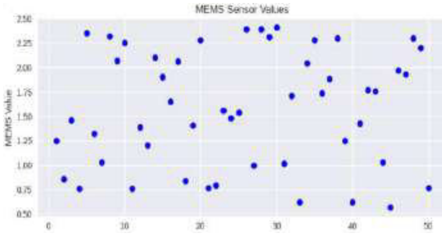

Fig. 6.3: MEMS Sensor Readings

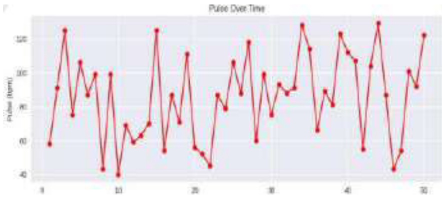

Fig. 6.4: Pulse Values Over Time

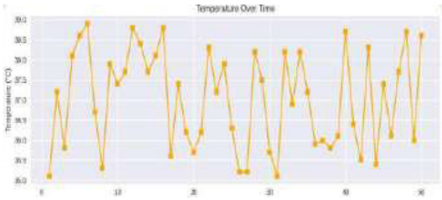

Fig. 6.5: Temperature Values Over Time

The geo-fencing module accurately delineated a virtual perimeter around the patient's permitted zone using GPS coordinate data. Whenever the patient's tracked position moved outside this boundary during testing, the system correctly identified the violation and immediately transmitted an SMS alert containing the real-time GPS coordinates to the caregiver, enabling prompt response and patient retrieval. All core functionalities of the system — real-time health monitoring, timely medication reminders, continuous location tracking, and automated safety alerts — performed reliably and efficiently throughout the evaluation period. These results confirm that the proposed solution holds strong practical potential in supporting dementia patients and the elderly in maintaining medication adherence and personal safety.

5. Conclusion and Future Work

This work has successfully demonstrated a unified, embedded solution that merges real-time health surveillance, intelligent location tracking, and automated medication management within a single compact device. By leveraging the Arduino UNO microcontroller in conjunction with GPS, GSM, and multiple biosensing technologies, the system ensures adherence to prescribed medication schedules while maintaining patient safety within defined geographic boundaries. The ability to deliver immediate emergency notifications further strengthens its utility as a dependable assistive technology for dementia patients and elderly individuals. Overall, this project underscores the transformative potential of embedded systems in modern healthcare and remote patient care applications.

Future Scope

- Development of a companion mobile application to enable live GPS tracking and push-based alert notifications for caregivers.
- Migration to IoT-enabled cloud infrastructure for scalable remote data storage, analysis, and longitudinal health trend visualization.
- Introduction of voice-command-driven medication reminders to improve accessibility for patients with limited motor skills.
- Interfacing with commercial smartwatches or wearable biosensor bands for enhanced portability and unobtrusive monitoring.

References

[1] Ullah, S.; Mumtaz, Z.; Liu, S.; Abubaqr, M.; Mahboob, A.; Madni, H.A. Single-equipment with multiple-application for an automated robot-car control system. Sensors 2019, 19, 662.

[2] M. Patel and A. Aggarwal, "Low-cost GSM/GPS based tracking system," in IEEE Transactions on Consumer Electronics, vol. 58, no. 2, pp. 364-371, 2012.

[3] Ben Hassine, Mariem & Tounsi, Imen & Hadj Kacem, Mohamed. (2023). Developing IoT-based Smart Health Monitoring Systems using Design Patterns. 1-8. 10.1109/AICCSA59173.2023.10479310.

[4] S. Banka, S. Kancharla, T. Purnima, A. Thanvi, and L. Shatdarsanam, "Patient Health Monitoring System Using IoT Technology," International Journal of Creative Research Thoughts (IJCRT), vol. 11, no. 10, Oct. 2023.

[5] Dr. S. Durgadevi, R Anbazhagan, A. Vimonisha, R Harini, 2022, Design and Implementation of An Health Monitoring System using IOT, INTERNATIONAL JOURNAL OF ENGINEERING RESEARCH & TECHNOLOGY (IJERT) ICONNECT – 2022 (Volume 10 – Issue 09).

[6] A. Jemina, M. Pechiammal, M. Ponnarasi, R. Indhu, and V. Namakkani, "Design and Implement a Health Care Monitoring and Management System Using IoT," Data Analytics and Artificial Intelligence, vol. 3, no. 6, REST Publisher, 2023. ISBN: 978-81-948459-4-2.

[7] Ravishankar, V., Ibrahim, M., Jain, A., & Verma, N. (2024). Design and Implementation of an IoT-Based Patient Monitoring System for Comprehensive Vital Tracking and Secure Data Access. International Journal of Microsystems and IoT, 2(7), 1044–1049. https://doi.org/10.5281/zenodo.13332142.

[8] S. Birajadar, N. H. Aiwale, S. H. Chavan, D. M. Patil, and D. S. Patil, "IoT Based Health Monitoring System," International Journal of Novel Research and Development (IJNRD), vol. 9, no. 5, May 2024. ISSN: 2456-4184.

[9] B. Lakshmi, M. Lavanya, R. Haripriya, K. Sushma Sri, M. Teja, and M. Jayasri, "Design and Implementation of IoT Based Smart Health Monitoring System for Diabetic Patients Using Wireless Sensor Networks," International Journal of Information Technology (IJIT), vol. 8, no. 3, May–Jun. 2022.

[10] R. Baske, P. V. Jadhav, R. T. Shaikh, and S. S. Bondre, "IoT Based Health Monitoring System Using ESP 32," Journal of Emerging Technologies and Innovative Research (JETIR), vol. 12, no. 5, May 2025. ISSN: 2349-5162.