Wearable Device for Dementia Patients

EN 1190: Engineering Design Project

University of Moratuwa

Faculty of Engineering

Department of Electronics and Telecommunication Engineering

Team InnovaTech

Name	Index
Ranathunga R.J.K.O.H.	230525U
Wedamestrige A.N.	230687P
Prabharsha H.W.D.	230495B
Garusinghe S.B.	230197M

Contents

1 Problem Description

Problem

Wandering is a common and worrying behavior among people living with dementia, especially in the moderate to advanced stages of the disease. Many patients leave their homes or care facilities without warning, often confused and unable to find their way back. This puts them at serious risk of accidents, injuries, getting lost, or even worse, if they are not found quickly.

In Sri Lanka, most families care for their loved ones at home, but with limited formal support services, providing round-the-clock supervision is a huge challenge. This constant responsibility causes significant stress and worry for caregivers. Sadly, traditional methods like manual watching or simple alarms often fail to prevent incidents. There is a real need for an affordable, practical, and easy-to-use solution that can help keep dementia patients safe and ease the daily burden on families who look after them.

Justification for Problem Selection

Dementia is a significant and escalating global health crisis, profoundly impacting individuals and their families. This condition arises from damage to brain cells, disrupting their ability to communicate effectively. Such damage can stem from various causes, including diseases like Alzheimer's, reduced cerebral blood flow (vascular dementia), atypical protein deposits (Lewy bodies), or other degenerative neurological conditions. Consequently, individuals with dementia frequently experience memory loss, disorientation, and a heightened propensity for wandering into unsafe environments, leading to potentially hazardous situations.

The global prevalence of dementia is staggering and on an upward trajectory. In 2020-2021, an estimated 55-57 million people were living with dementia worldwide, with approximately 10 million new diagnoses annually. Projections indicate a substantial increase in cases, reaching 82 million by 2030 and a remarkable 152 million by 2050. Dementia affects roughly 7% of individuals over 65, with prevalence rates escalating from about 3% in the 65-74 age group to nearly 50% in those 85 and older. The mortality rate associated with dementia has also seen a sharp rise, from 0.56 million deaths in 1990 to 1.62 million in 2019, with an anticipated 4.91 million deaths by 2050.

Sri Lanka mirrors this global demographic shift. By 2023, approximately 11.7% of its population was aged 65 or older, a notable increase from previous years, and this figure is projected to exceed 25% by 2041. In Sri Lanka's rural and semi-urban areas, the prevalence of dementia among seniors is approximately 3.98%.

The worldwide aging of populations, including in Sri Lanka, directly correlates with an escalating number of seniors and, consequently, a rise in dementia cases. This demographic trend underscores the urgent need to address the challenges posed by dementia.

Proposed Solution

To address the growing challenges faced by dementia patients and their caregivers, **we propose an affordable, wearable smartwatch system designed to improve safety and provide real-time monitoring**. This solution combines modern IoT technology, low-cost hardware, and user-friendly design to help families manage dementia care more effectively, especially in Sri Lanka.

Our solution integrates a GPS module for real-time location tracking, a GSM module for communication with caregivers via mobile networks, and a motion sensor to detect abnormal movements such as falls. The smartwatch continuously monitors the patient's location and sends alerts if they leave a predefined safe zone or if a fall is detected. This enables caregivers to respond quickly, improving patient safety and providing peace of mind. The device is designed to be lightweight, comfortable, and easy to use for elderly individuals, while also being cost-effective for families in Sri Lanka.

Comparison with Existing Solutions

Although several tracking devices and smartwatches for dementia patients are already available globally, many of these products have significant limitations when applied in the context of Sri Lanka. Existing solutions tend to be:

- Expensive, making them inaccessible for many families in low- and middle-income regions.
- Bulky or uncomfortable, reducing patient compliance for continuous wear.
- Limited local support and customization for the specific needs of Sri Lankan users, such as language barriers or local network compatibility.

Our project aims to overcome these challenges by creating a cost-effective, easy-to-use smartwatch system tailored to local conditions. It uses affordable components, simple communication methods like SMS alerts, and a comfortable wearable design, making it suitable for everyday use by dementia patients and their caregivers in Sri Lanka.

2 Product Feasibility

Technical Feasibility

The proposed solution is technically feasible because it uses widely available, cost-effective electronic components and well-established technologies. The ESP32 microcontroller, GPS, SIM800L, and MPU6050 are widely used and fully compatible with mobile app communication via internet or GSM.

- The ESP32 can connect to the internet via GSM or Wi-Fi to send patient location and status data to a dedicated mobile app. This app provides caregivers with an intuitive interface for real-time monitoring, geo-fencing setup, and instant notifications.
- The mobile app can be developed using common frameworks such as Flutter or React Native, which allow faster development and compatibility with Android devices.
- Instead of relying solely on SMS, the mobile app allows richer data (e.g., maps, reset memory, restart, send message) and better user control while still using mobile networks for areas with limited Wi-Fi.
- The device is powered by a 3.7 V, 800 mAh, 25C LiPo battery, which provides a lightweight, compact energy source suitable for continuous wearable use. The TP4056 module ensures safe recharging via USB.
- The MPU6050 sensor module combines a 3-axis accelerometer and a 3-axis gyroscope to monitor the patient's movements in real-time. It detects abnormal motion patterns such as sudden falls or impacts. The data is processed by the ESP32, and an alert is generated if an unusual event is detected.

The custom-designed PCB integrates all the essential modules on a compact board, ensuring stable electrical connections and efficient signal transmission while keeping the overall form factor small enough for a wearable enclosure. The smartwatch enclosure was designed using 3D modeling tools and fabricated through collaboration with Rysera Innovations and NMW Robotics, who provided high-quality 3D printing and prototyping services. This approach ensured that the enclosure met the required standards for fit, durability, and user comfort while keeping production local and cost-effective.

Hardware Feasibility

The proposed smartwatch system is hardware-feasible because it uses affordable, widely available electronic components and proven fabrication methods that are within the capability of the team to assemble and test. Key aspects that prove hardware feasibility include:

- ESP32 microcontroller
- SIM800L GSM module
- MPU6050 accelerometer/gyroscope
- 3.7 V, 800 mAh, 25C LiPo battery
- TP4056 charging module
- GPS module

Software Feasibility

The proposed system is also feasible from a software perspective because it relies on well-established development platforms, straightforward programming requirements, and technologies that are well supported by existing resources and tools.

- The ESP32 microcontroller will be programmed using the Arduino IDE which provide extensive libraries and community support for modules like GPS, GSM (SIM800L), and MPU6050 sensors. This makes it easy to integrate location tracking, motion detection, and communication functions.
- The mobile app is being developed using Kotlin in Android Studio, which is the official IDE for Android development. Using Kotlin ensures modern, clean, and efficient code that fully leverages Android's capabilities. Native development provides better performance, easier access to phone features (like notifications, maps, and SMS handling), and smooth user experience for caregivers.
- Kotlin and Android Studio allow the team to build a clear, user-friendly interface with map integration (e.g., Google Maps API), custom alerts, and easy controls for caregivers.

3 Product Applications

The proposed smartwatch-based tracking and safety system is primarily designed to assist dementia patients and their caregivers:

- Monitoring Dementia Patients
- Elderly Care
- Patient Monitoring in Hospitals

Mobile application

The proposed system includes a custom-developed mobile application designed to work seamlessly with the smartwatch hardware. The mobile app acts as the user interface for caregivers, enabling them to monitor and manage the safety of dementia patients in real time. Our mobile application includes a lot of features like:

- Receives location and motion status data from the smartwatch via GSM/mobile network.
- Displays the patient's live location on an interactive map.
- Provides instant notifications if the patient leaves a predefined safe area (geo-fence) or if a fall is detected.
- Allow caregivers to set or adjust safe zones easily.

4 Product Specifications

Parameter	Specification
Communication Method	GSM (SMS / Data for Mobile App Communication)
Estimated Size	Compact, wrist-wearable form factor (custom PCB). 59mm x 55mm x 35.6mm enclosure box
Operating Time	
Indicators	**Charging LED:** Shows charging status and charge completion **Status LED:** Indicates Wi-Fi connected, fall detected, or safe zone exited
Microcontroller	ESP32 Development Board
Location Module	GPS Module (NEO-6M)
Communication Module	SIM800L GSM Module
Motion Sensor	MPU6050 (3-axis Accelerometer + 3-axis Gyroscope)
Battery	3.7 V, 800 mAh, 25C LiPo Battery
Charging Circuit	TP4056 Li-Ion Charging Module

Table 1: Product Specifications

5 Product Architecture

The proposed smartwatch-based tracking and safety system is designed with a clear modular architecture that integrates hardware components, embedded software, and a native mobile application to deliver real-time monitoring and alert functionalities.

The hardware consists of several integrated modules mounted on a custom PCB:

Hardware architecture

- ESP32 Microcontroller - Acts as the central processing unit, managing data from all sensors and modules.
- GPS Module - Provides real-time location data to ESP32.
- SIM800L GSM Module - Handles mobile network communication, allowing the system to send location and alert data to the mobile application via SMS or internet.
- MPU6050 Sensor - Continuously monitors the patient's movements and detects falls using accelerometer and gyroscope data.
- Power Supply - Powered by a 3.7 V, 800 mAh, 25C LiPo battery with a TP4056 charging circuit.
- Indicators -
  - Charging LED: Shows the battery's charging status and charge completion.
  - Status LED: Indicates Wi-Fi connectivity and provides visual alerts for fall detection or geo-fence breaches.
- Enclosure - All hardware is enclosed in a lightweight, ergonomic, 3D-printed smartwatch casing for comfortable daily use.

Software architecture

The system's software architecture has two main parts:

1. Embedded Software:
   - Runs on the ESP32 microcontroller.
   - Continuously collects data from the GPS module and MPU6050 sensor.
   - Detects safe zone breaches and falls using programmed logic.

- Communicate with the SIM800L module to send alerts and location data.
- Controls the status LED to provide immediate visual feedback.

2. Mobile Application:

   - Developed natively in Kotlin using Android Studio.
   - Receives data from the smartwatch via GSM/SMS or mobile data.
   - Displays the patient's live location on a map.
   - Send notifications for safe zone exits and falls.
   - Provides a simple interface for caregivers to view alerts and manage safe zone settings.

Block Diagram

Figure 1 shows the block diagram of our product.

1. ESP32

   - The ESP32 is the central microcontroller. It collects data from the GPS, Accelerometer, and (in your diagram) a Heart Rate Sensor. It processes this data to detect patient's real-time location, patient's motion status (e.g., fall detection), vital signs. It controls communication with the GSM module to send alerts.

2. GSM Module

   - The GSM module connects the system to the mobile network. It sends SMS messages or mobile data with the patient's location and alert status (fall detected, left home, etc.). It may receive simple commands from the caregiver's mobile app if needed.

3. GPS Module

   - The GPS module receives signals from GPS satellites. It continuously provides latitude and longitude data to the ESP32. This is used for real-time location tracking and geo-fencing.

4. Accelerometer

   - The Accelerometer detects motion and orientation. It monitors sudden changes in movement to detect falls. ESP32 uses this data to trigger alerts if abnormal motion is detected.

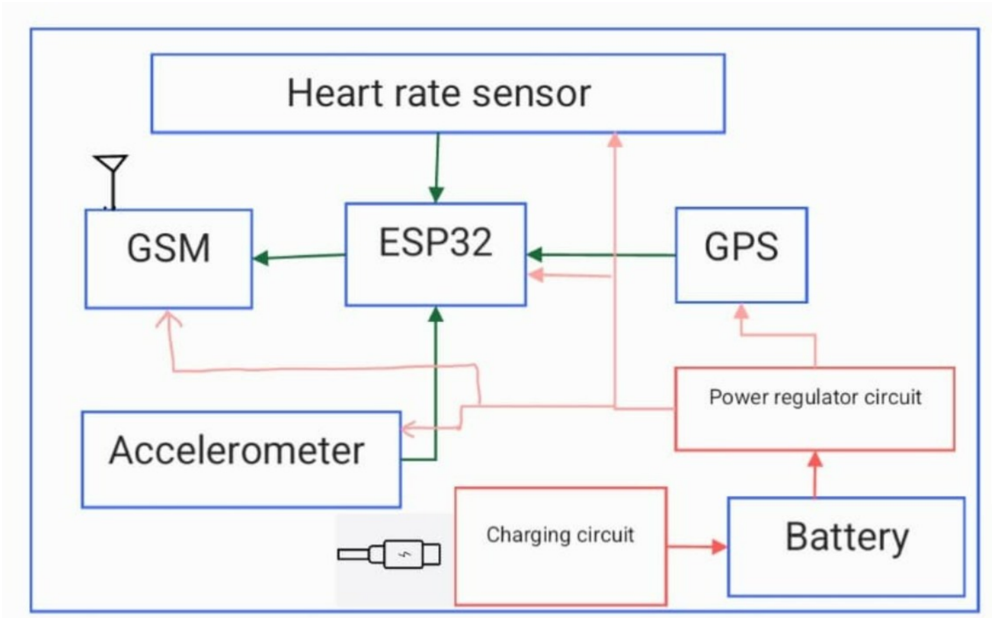


Figure 1: Block Diagram

5. Heart Rate Sensor
   - This would monitor the patient's pulse. The ESP32 can process this data for additional health tracking.
6. Battery
   - The Battery is a 3.7 V, 800 mAh LiPo cell. It provides portable power for the entire system.
7. Charging Circuit
   - This is the TP4056 charging module. It safely charges the battery via USB. It also manages charging status (with the Charging LED).
8. Power Regulator Circuit
   - Converts the battery's raw 3.7 V to stable voltage levels required by the ESP32, GPS, GSM, and sensors. Ensures each module gets the correct voltage and current to operate reliably.

6 Enclosure

Initial Sketch

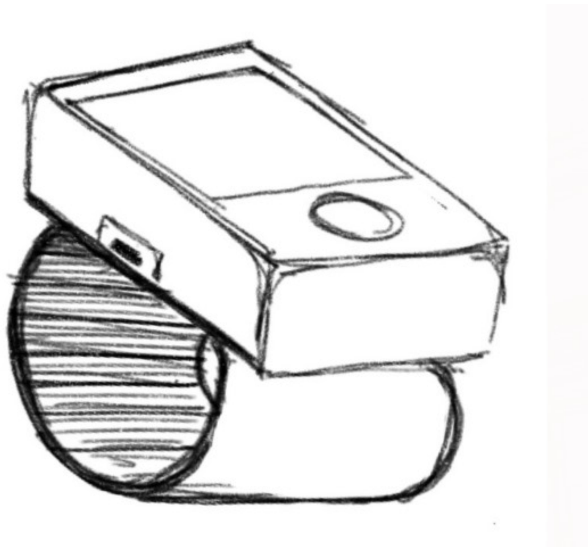
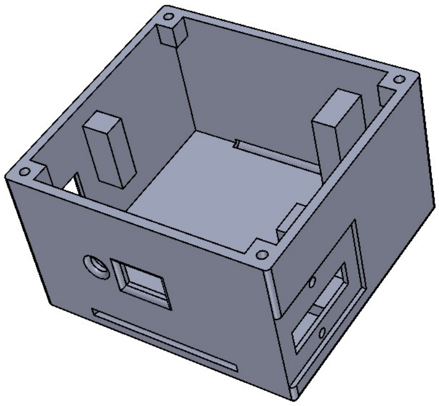


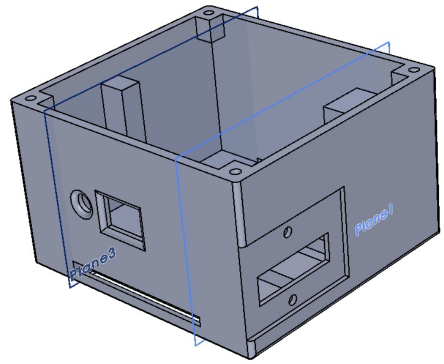
Figure 2: Initial sketch

Figure 3: Final Product

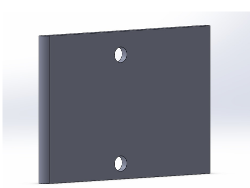
Final Enclosure



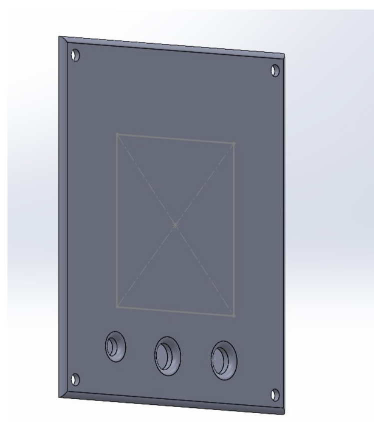
(a) Enclosure Design - View 1



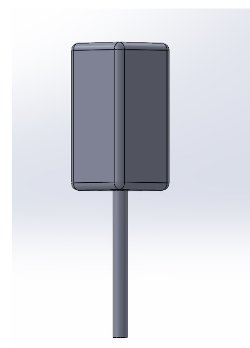
(b) Enclosure Design - View 2



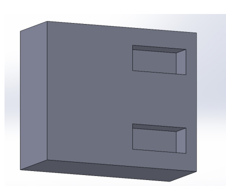
(c) SIM Lid



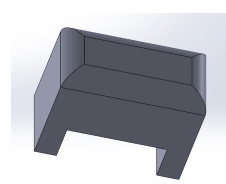
(d) Top Lid



(e) Push Button Mechanism



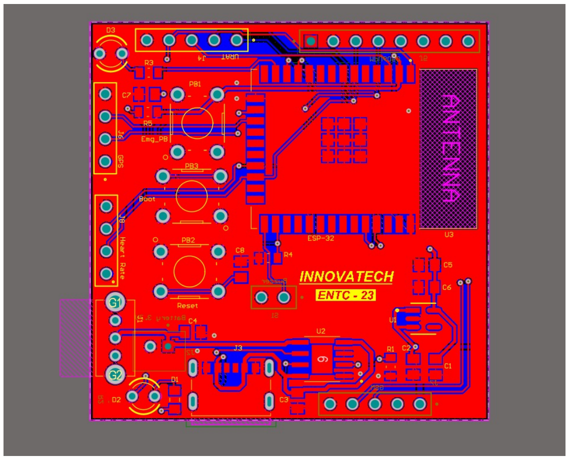
(f) Switch Part - View 1



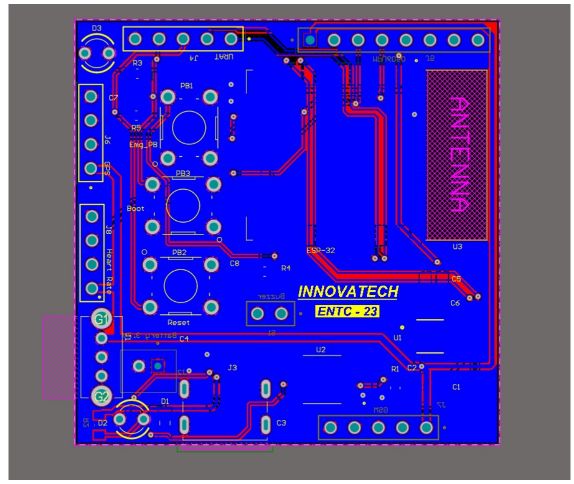
(g) Switch Part - View 2

Figure 4: 3D Model Components of the Smartwatch Enclosure and Assembly

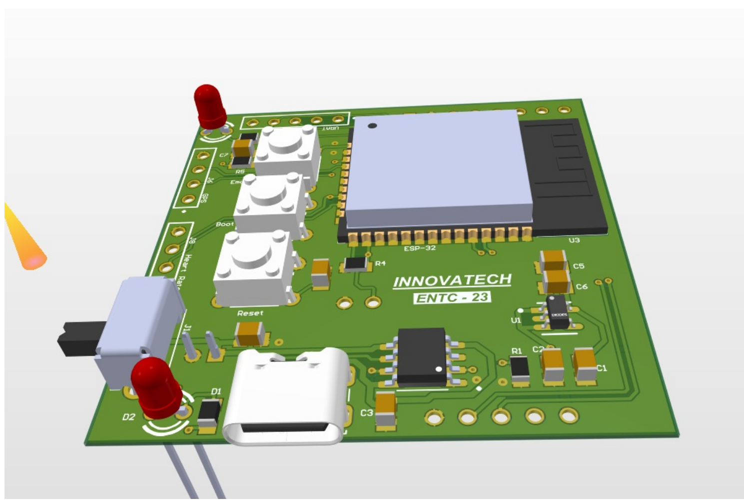
7 PCB Design



(a) Top layer



(b) Bottom layer



(c) 3D Model

Figure 5: PCB

Schematic

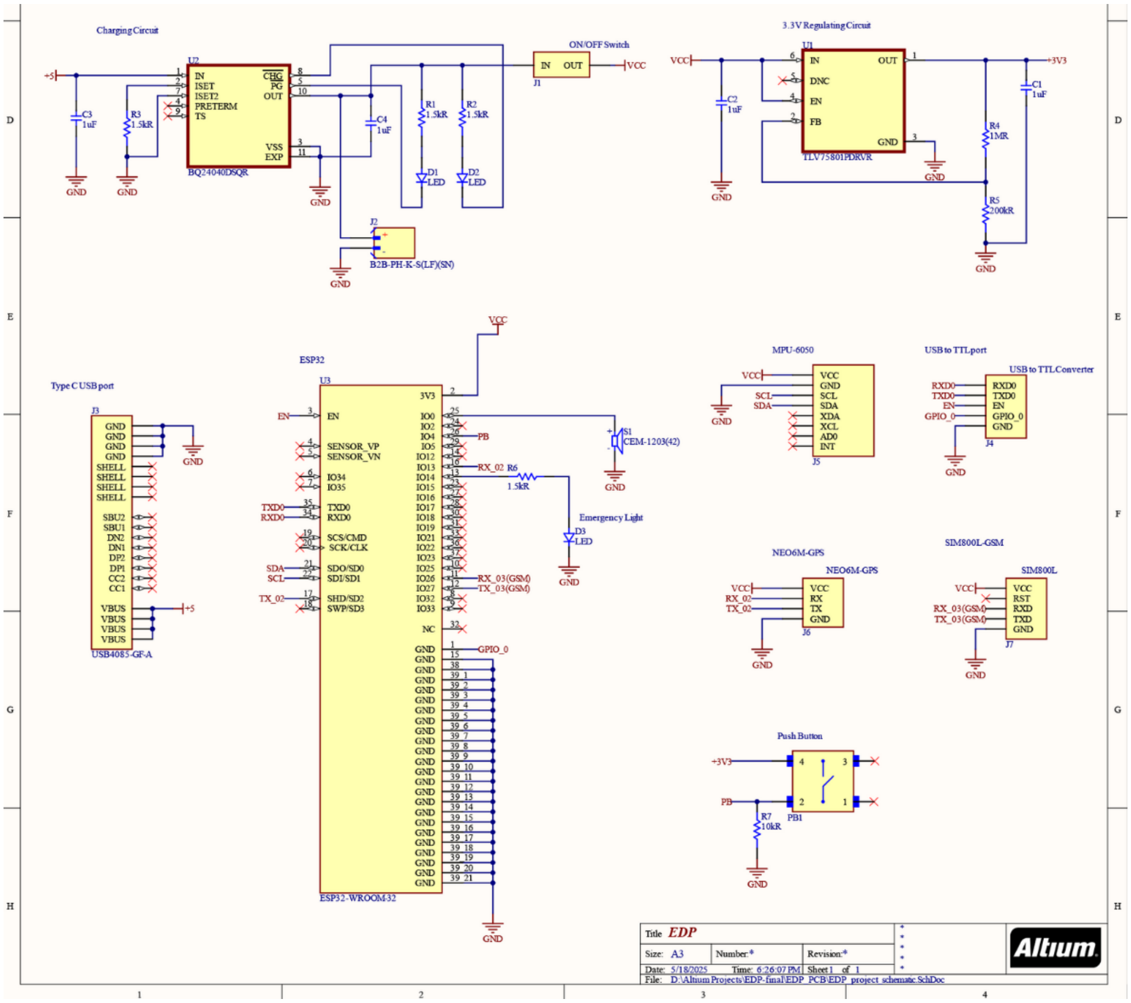
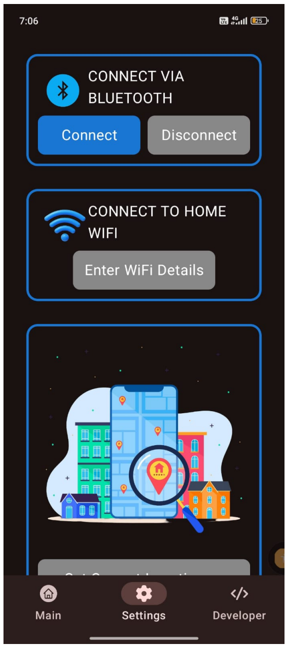
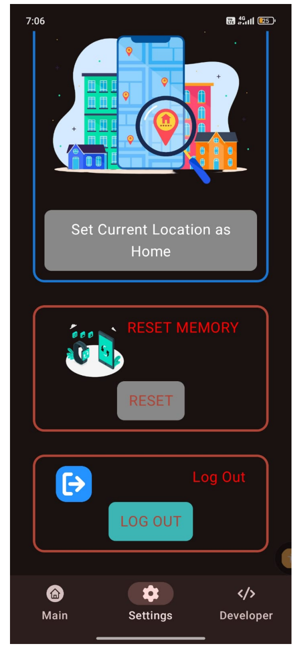


Figure 6: Schematic

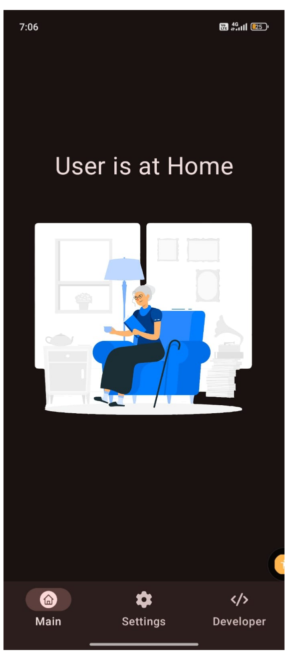
8 App Design



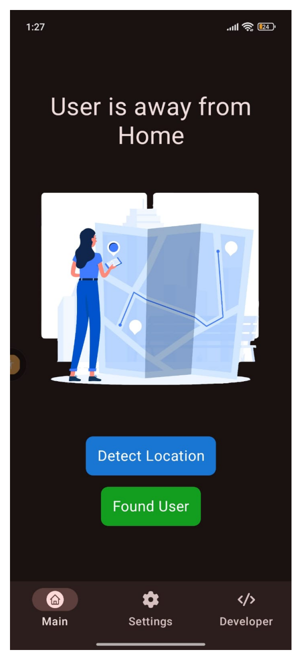
(a) Settings



(b) Device setup

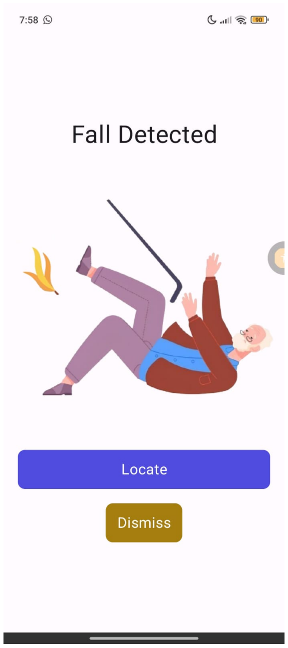


(c) User is at home

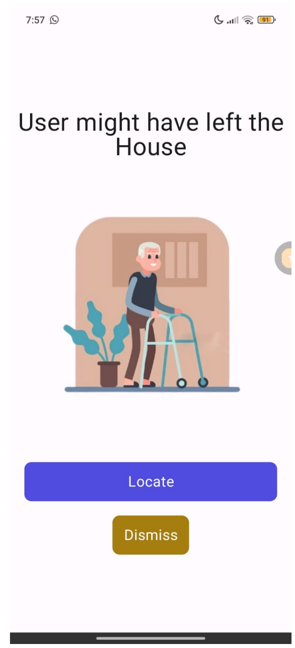


(d) User is away from home

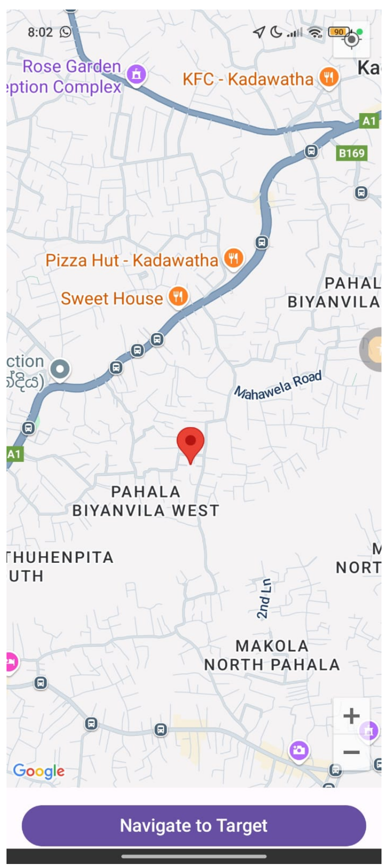
Figure 7: App Design



(a) Fall detected



(b) User have left the home



(c) Location Tracking

Figure 8: App Design

9 Market Analysis

The proposed smartwatch-based tracking and safety system addresses a growing need for effective patient monitoring solutions, especially for vulnerable groups such as dementia patients. The aging population, increasing cases of Alzheimer's disease, and the lack of affordable, easy-to-use tracking devices create a significant market opportunity. Globally, more than 55 million people live with dementia, and this number is expected to double every 20 years due to aging populations (WHO, 2023). In Sri Lanka alone, an estimated 200,000–250,000 people live with dementia. A key challenge facing families is and accidental falls fromfalls from patients,nts, which can lead to severe injuries or death if not addressed quickly. Existing GPS-based patient tracking and medical alert devices typically range from LKR 8,000 to more than LKR 90,000, depending on features and brand. High-end solutions may also require monthly recurring subscription fees, which are unaffordable to many families in Sri Lanka. This highlights the clear need for a low-cost, locally produced alternative with integrated tracking, geofencing, and fall detection at an affordable price point. Sri Lanka is experiencing a steady increase in the elderly population, with people over 60 projected to make up more than 20% of the population by 2030. However, affordable technological solutions for elderly care are still limited in the local market. A locally developed, low-cost, customizable smartwatch system with tracking and safety features could fill this gap. Using low-cost modules, the product can be made more accessible than imported alternatives.

Pricing

It cost about 8000 LKR for our product with available modules. But if we are mass producing it would cost less than this price. Including the costs of marketing, the salaries of the employees and other costs would add up. Keeping a considerable profit margin, price would be around 10,000 LKR.

10 Task Allocation

Name	**Task allocation**
Wedamestrige A.N. (230687P)	PCB Design, Circuit Analysis and Design
Ranathunga R.J.K.O.H. (230525U)	Mobile App Design
Garusinghe S.B. (230197M)	Enclosure Design
Prabharsha H.W.D. (230495B)	Enclosure Design

Table 2: Task Allocation

11 Final Budget

Component	**Unit Price (Rs.)**	**Quantity**	**Total Price**
ESP32 WROOM 32 Microcontroller	1350	1	1350
SIM800L GSM Module	1250	1	1250
NEO-6M GPS Module	1100	1	1100
MPU6050 Sensor	700	1	700
3.7 V, 800 mAh, 25C LiPo battery	830	1	830
LED	20	2	40
Push button	5	2	10
PCB	800	1	800
Enclosure	900	1	900
Other Electronic components	-	-	200
Total			**8180**

Table 3: Final Budget