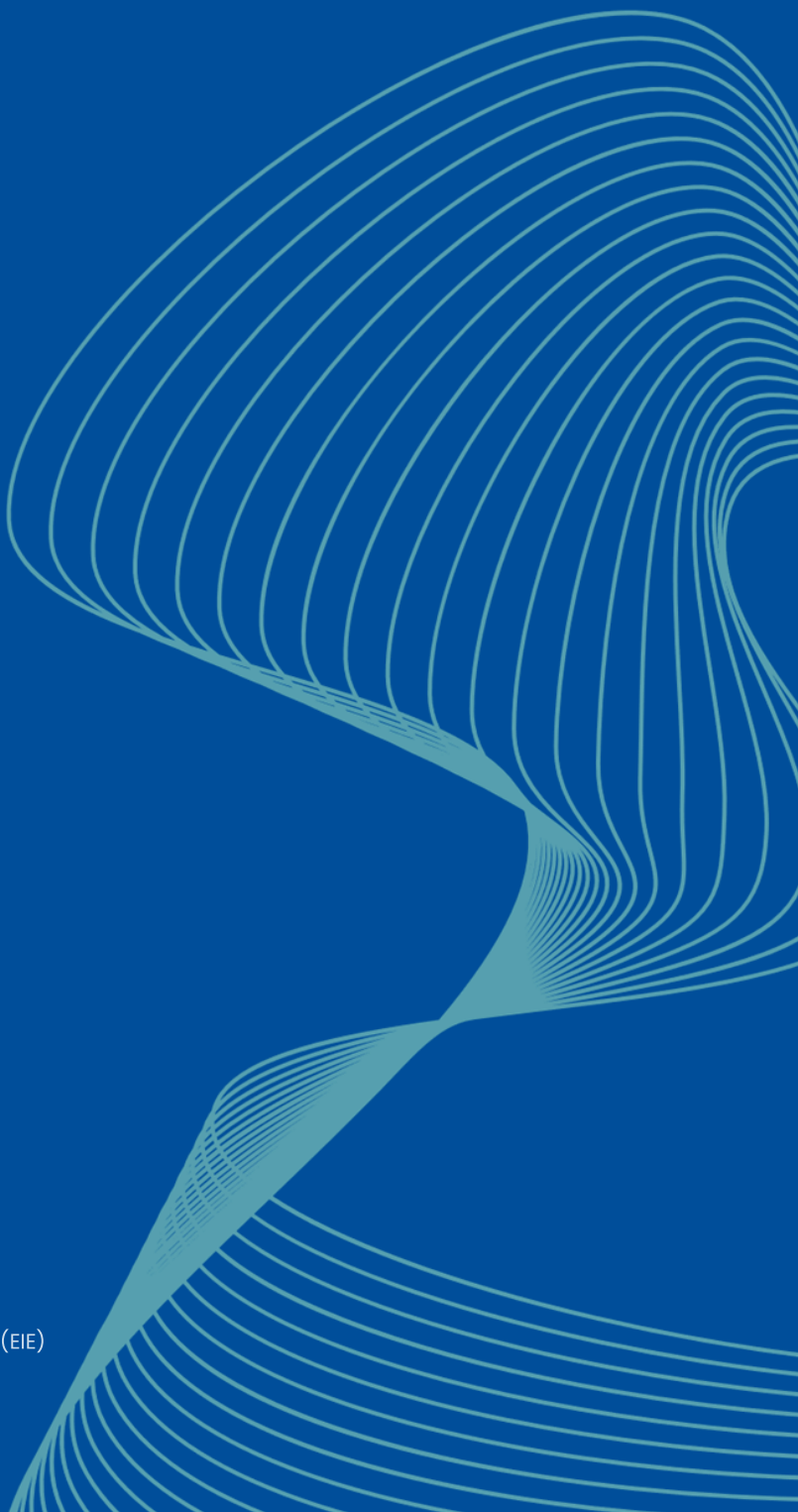
SYSTEM REQUIREMENTS

Version 1.1 – 20/03/2024



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SAXION

Abbreviation

ESP32: Espressif Systems 32-bit microcontroller

OLED: Organic Light Emitting Diode

GPS: Global Positioning System

IoT: Ineternet of things

UI: User Interface

PCB: Printed Circuit Board

ACS: Applied Computer Science

EIE: Electrical Information Engineering

IEC: International Electrotechnical Commission

EMC: Electromagnetic Compatibility

CE: Conformité Européene

MTBF: mean time before failure

MTTR: mean time to repair

BMS: battery management system

Glossary

EMC standards ensure that electronic and electrical products do not interfere with each other.

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1- Background

1.1 Project summary

- This project focuses on the development of:
- A Personal Safety Device that detects epileptic seizures with fall detection emergency to enhance personal safety and reduce the risk of hard seizures that might be fatal.
- A Personal Medication Reminder System UI that assists epileptic patients with their medication.

1.1.1 Project Goal

- The Medication Reminder System UI that targets epileptic patients to schedule their medication and to get a reminder/notification if the medication time came.
- The Personal Safety Device aims to enhance user safety and provide peace of mind to individuals and caregivers.

1.1.2 Overview of the Document

This document outlines the requirements, specifications, and functionalities for both systems, serving as a guide for developing the system.

2- Functional description and requirements

2.1 Functional description

The Personal Safety Smartwatch is a compact device designed to detect elliptical seizures, initiate fall detection emergencies, and provide medication reminders. It features an easy-to-use user interface, long battery life, and affordable price. In addition to have wireless connectivity and personalized alerts.

Personal safety watch functional description in normal state:

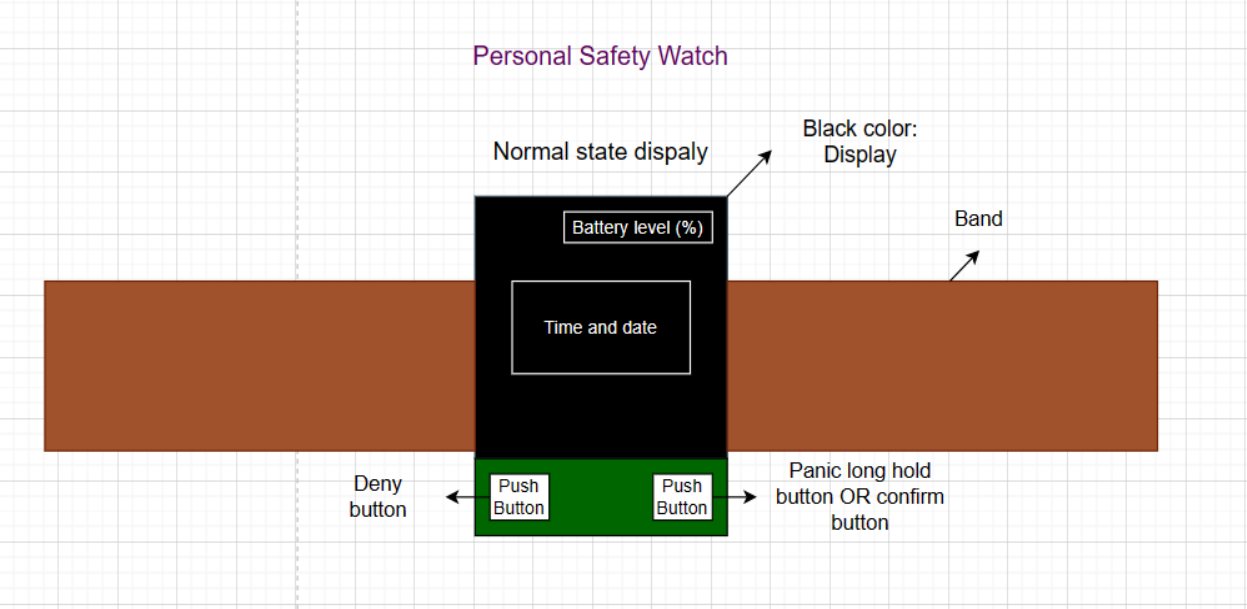

Figure 1 - Personal Safety device in normal state.

The previous image shows the personal safety watch in the normal state, where it shows the display that will show the battery life, the time and date.

A long hold panic push button is also shown for cases where the user feels in trouble and needs help.

Personal safety watch functional description in emergency state:

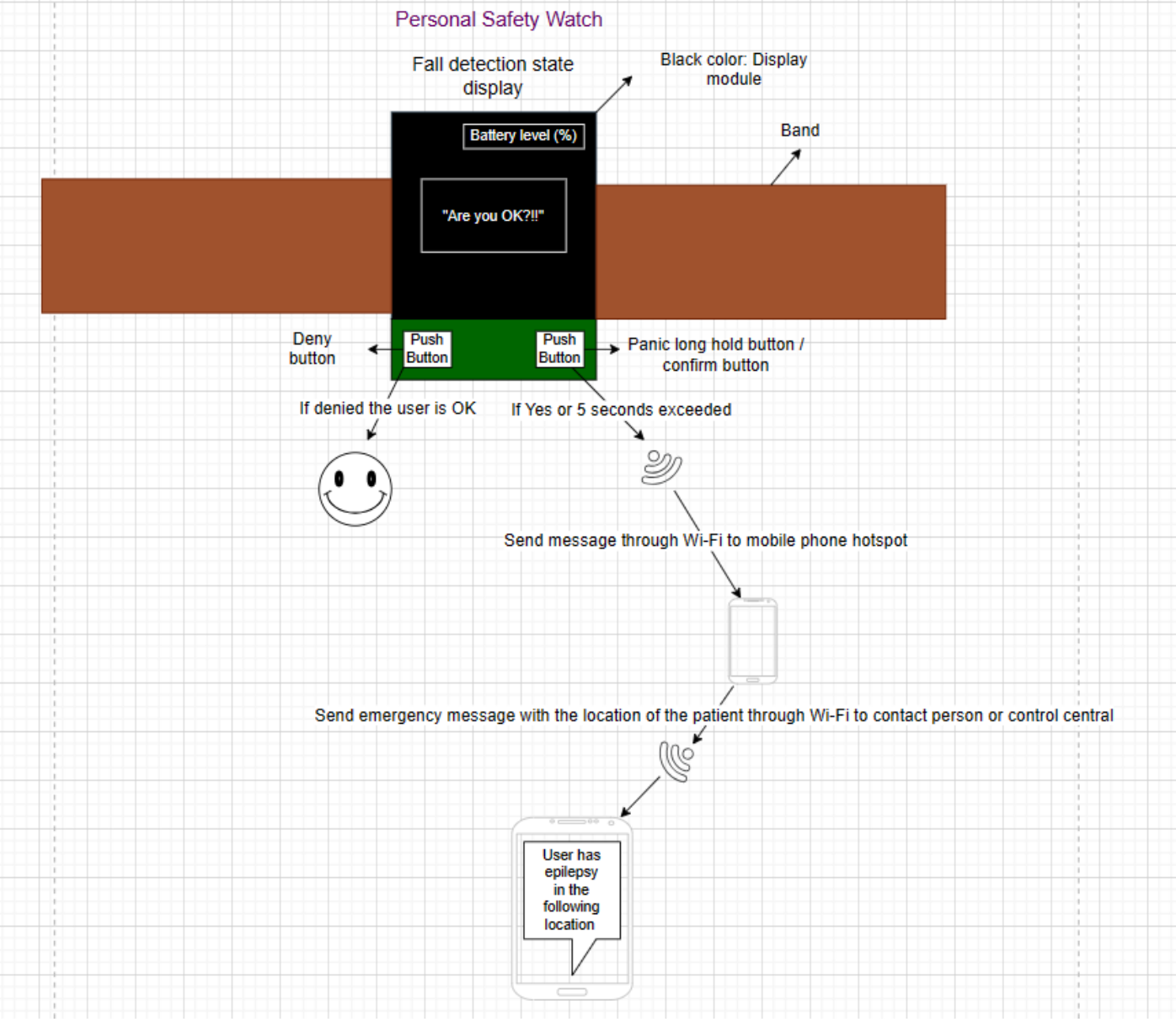

Figure 2 - Personal safety watch in emergency state.

The previous image shows the personal safety watch in emergency state. If a fall is detected a notification in the watch's display will show up as shown in the image "Are you OK?". If the deny button is pressed, then the user is ok.

Otherwise, within approximately 5 seconds if the user did not react to the notification. Then an emergency signal with the location will be sent from the microcontroller to the user's mobile hotspot, which will be forwarded to the contact person or the control center.

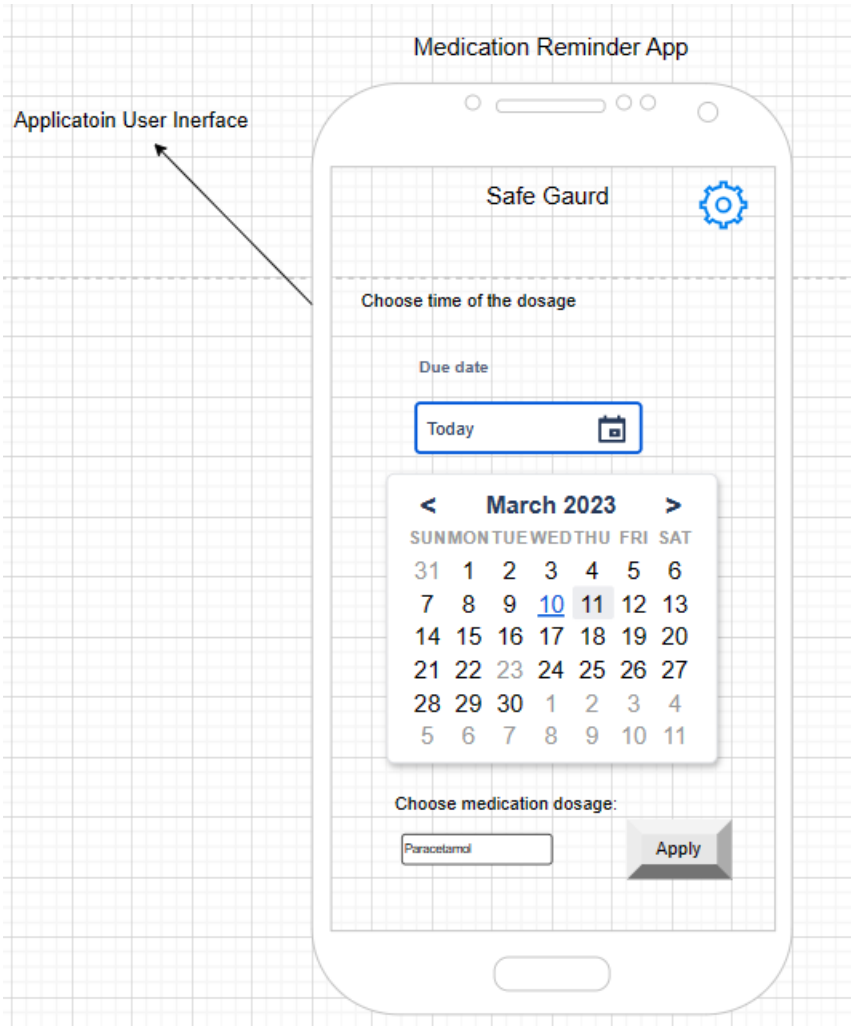

Figure 3 - Medication reminder application.

The previous image explains how the application user interface will look like. The user will be able to input a date, time, and dosage. And can change the setting for his preference, for instance changing the UI theme to dark mode and insert or change an emergency number to the personal safety device.

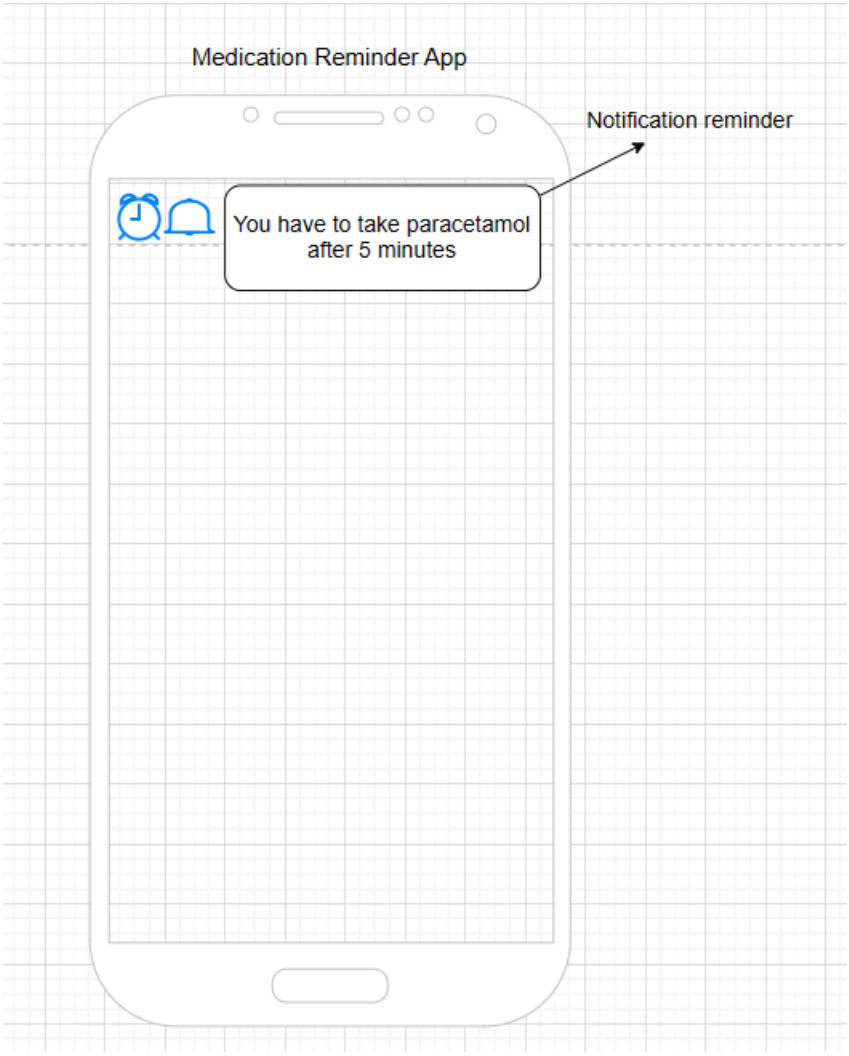

Figure 4 - Medication system mobile notification.

The previous image clarifies that after the user has set the date, time, and the dosage of the modification. A mobile notification will be sent to him or her 5 minutes before the dosage intake.

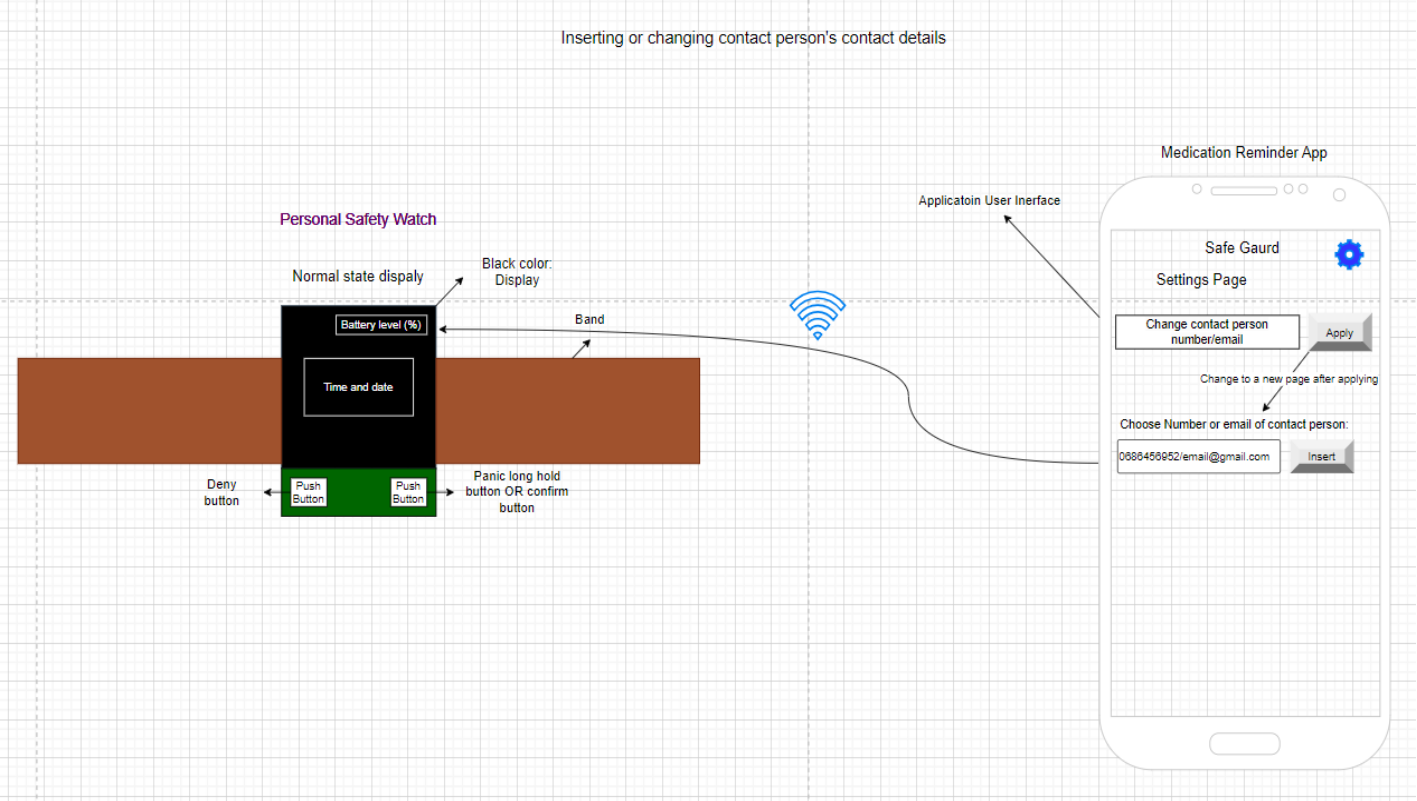

Figure 5 - Inserting a contact person's number or email.

In the previous image the functionality of inserting or changing a contact's person number or mail is explained simply. The user will be able to change the contact person's contacts wirelessly using Smart Guard's Application.

2.1.1 Use Scenarios

Automated Medication Reminder System

Normal Operation

- **Start Condition:** User sets medication schedule through the mobile app.
- **Sequence:** The system sends reminders to the user's phone or via email/SMS.
- **End Condition:** User confirms medication intake.

Faulty Operation

- **Start Condition:** The system encounters an error in communication.
- **Sequence:** User receives an error notification through the app or screen.
- **End Condition:** User troubleshoots the issue or contacts support for assistance.

Production

- **Start Condition:** Manufacturing process begins for the Automated Medication Reminder System.

- **Sequence:** Components are assembled, firmware is installed, and quality checks are conducted.
- **End Condition:** Finished products are packaged and ready for distribution.

Sale

- **Start Condition:** Finished products are available for purchase.
- **Sequence:** Customers purchase the system through online or retail channels.
- **End Condition:** Transaction is completed, and product ownership is transferred to the customer.

Personal Safety Device

Normal Operation
Start Condition: Device is powered on and activated.
Sequence: User wears the device, which monitors for falls and allows for panic button activation.
End Condition: Device remains on standby until another event occurs.

Faulty Operation
Start Condition: Device encounters a malfunction or communication error.
Sequence: User notices abnormal behaviour or receives error alerts.
End Condition: User attempts troubleshooting or contacts support for resolution.

Production
Start Condition: Manufacturing process initiates for the Personal Safety Device.
Sequence: Components are assembled, location tracking modules are integrated, and final testing is conducted.
End Condition: Finished devices are packaged and prepared for shipment.

Sale
Start Condition: Personal Safety Devices are available for purchase.
Sequence: Customers buy the device online or from retail stores.
End Condition: Transaction is completed, and ownership of the device transfers to the customer.

2.1.2 User Requirements

Automated Medication Reminder System

Clear Description

- Users should be able to set medication schedules through a mobile app.
- Reminders should be sent to users via phone, email, or SMS.

Completeness

- The system should accommodate diverse medication schedules and dosage frequencies.
- Users need the ability to easily adjust and update their medication schedules.
- Reminders should be customizable to suit individual preferences and needs.

Personal Safety Device

Clear Description

- Users require a panic button for immediate activation during emergencies.
- The device must detect falls and accurately track the user's location.
- Alerts should be sent to predefined contacts or a monitoring service upon activation.

Completeness

- The device should be wearable and comfortable for extended use.
- Users need assurance of accurate location tracking, especially during emergencies.
- It should offer long battery life and durability for reliable performance in various conditions.

2.1.3 Functions

Automated Medication Reminder System:

Medication Schedule Management

- Users can input and manage medication schedules through the mobile app.
- The system should allow for the customization of dosage times and frequencies.
- It should accommodate multiple medications and complex schedules.

Reminder Notifications

- Users should receive timely reminders via phone, email, or SMS.
- Reminders should include information about the medication and dosage.
- Notification preferences should be customizable for individual users.

Personal Safety Device

Emergency Activation

- The device must include a panic button for immediate activation during emergencies.
- Activation should trigger alerts to predefined contacts or a monitoring service.
- Emergency alerts should include the user's location for swift assistance.

Fall Detection

- The device should detect falls and distinguish them from other movements.
- Fall detection algorithms should be sensitive and accurate to minimize false alarms.
- Upon fall detection, the device should initiate emergency protocols automatically.

Location Tracking

- The device must accurately track the user's location using location tracking technology.
- Location data should be relayed in real-time to designated contacts or a central monitoring service.
- Tracking features should operate seamlessly in various environments and conditions.

2.1.4 Functional architecture

Mobile Application

- Allows users to input medication schedules and preferences.
- Provides user interface for setting reminders and receiving notifications.

Backend System

- Manages medication schedules and user preferences.
- Sends notification triggers to the communication module for reminder alerts.

Communication Module

- Facilitates communication between the system and users' devices.
- Receives acknowledgment from users regarding medication intake.

Hardware Components

- Includes panic button, fall detection sensors, location tracking module, and communication hardware.
- Collects and processes data from various sensors for emergency detection and location tracking.
- Interfaces with the communication module for alert transmission.

Fall Detection Algorithm

- Analyses sensor data to detect changes in acceleration and orientation indicative of a fall.
- Implements algorithms to distinguish falls from other activities or movements.
- Triggers emergency protocols upon fall detection.

Location Tracking System

- Utilizes location tracking technology to determine the user's precise location.
- Transmits location data to predefined contacts or a central monitoring service in case of emergencies.
- Ensures real-time tracking and accuracy of location information.

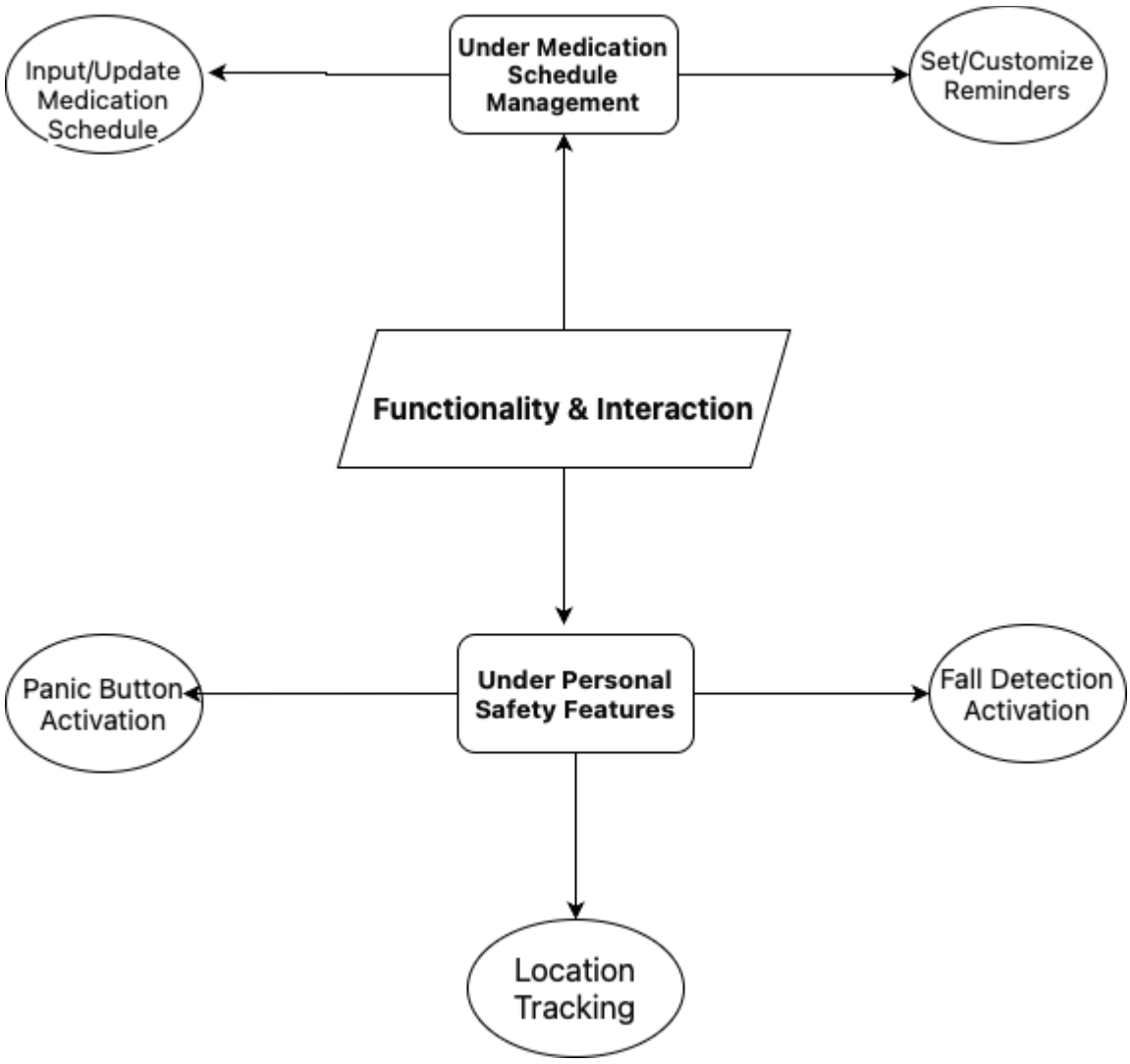

Figure 6 - Diagram of a Personal Safety and Medication Schedule Management System.

2.2 Functional requirements

2.2.1 Function1: User interface

Automated Medication Reminder System:

Function Number	*Function Description*
1.1	Input medication schedules
1.2	Set dosage frequencies and times
1.3	Customize reminder preferences
1.4	View medication schedule
1.5	Edit or update medication schedule
1.6	Receive reminder notifications

Personal Safety Device:

Function Number	*Function Description*
1.1	Activate panic button
1.2	Detect falls and initiate alerts
1.3	View real-time location tracking
1.4	Communicate with predefined contacts
1.5	Enable/disable device functionalities
1.6	Adjust device settings

Input Functions:

- Users input medication schedules, dosage frequencies, and reminder preferences in the Automated Medication Reminder System.
- They activate the panic button and adjust device settings in the Personal Safety Device.

Output Functions:

- Users receive reminder notifications and view medication schedules in the Automated Medication Reminder System.
- They receive alerts for falls and communicate with predefined contacts in the Personal Safety Device.

2.2.2 Function 2: Control Functions

Automated Medication Reminder System:

Function Number	*Description*	*Input Functions*	*Output Functions*
2.1	Control according to schedule	Medication schedule	Notifications
2.2	Update medication schedule	Updated schedule	Confirmation message
2.3	Manage reminder settings	Reminder preferences	Updated reminder settings

Personal Safety Device

Function Number	Function Description	Input Functions	Output Functions
2.1	Activate panic button	Panic button activation	Emergency alerts
2.2	Initiate fall detection	Fall detection sensors	Fall detection alerts
2.3	Enable/disable device functionalities	User commands	Confirmation message

Input-Output Relations

Automated Medication Reminder System:

- Function 2.1 controls based on the input medication schedule and generates notifications as output.
- Function 2.2 updates the medication schedule based on user input and confirms the update with a message as output.
- Function 2.3 manages reminder settings based on user preferences input and updates the reminder settings as output.

Personal Safety Device

Function 2.1 activates the panic button upon user input, generating emergency alerts as output.

Function 2.2 initiates fall detection based on sensor inputs and produces fall detection alerts as output.

Function 2.3 enables or disables device functionalities based on user commands and confirms the action with a message as output.

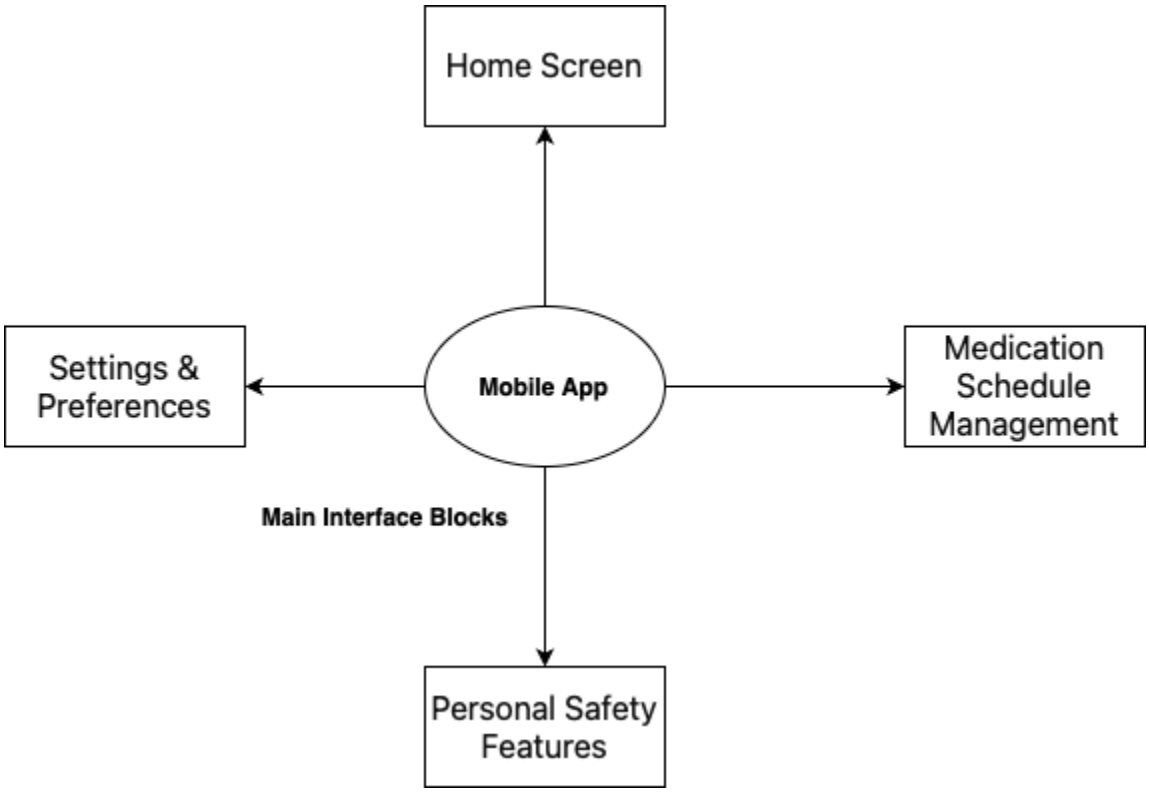

Figure 7 - Mobile App Interface Structure.

3- Design architecture and requirements

3.1 Design architecture

The goal of this chapter is to provide a clear overview of the design architecture and requirements of this project. The team will use this chapter as a roadmap how the system will be made and what functionalities it will have. The stakeholders can also use this chapter to understand what to expect from the system.

3.2 Technical requirements

3.2.1 Safety

In the following table safety requirements are present in a structural table format. CE standard is going to be the main safety standards that will be ensured.

Hardware safety table

No.	*Requirements*	*Standard*	*Compliance Method*
1	Battery must be encased to prevent leakage and exposure	CE	Enclosure design and material selection
2	Device must be automatically shut down in case of over heating	CE	Thermal sensors
3	Electronic components must comply with EMC standard	CE	Electromagnetic compatibility measures

Software safety table

No.	*Requirements*	*Standard*	*Compliance Method*
1	Software must ensure safe handling of errors and exceptions	CE	Implementation on error handling and error logging
2	Software must prevent memory leakage	CE	Use of static analysis tools and dynamic memory monitoring
3	Software must have a mechanism to recover from failure states	CE	Usage of watchdog timer and safe state transition

3.2.2 Cost

In this subchapter the whole costs of this project will be covered in aspect of components, labour, and special equipment. A table listing all costs of components associated with the system will be numbered.

Components

No.	**Quantity**	**Component**	**Cost per component**
1	2	Microcontroller	€ 2,67- 4,19

2	2	Location tracking module	€ 12,56
4	2	Battery	€ 20
5	2	OLED Display	€ 26,40
6	2	Battery Charger	€ 11.06
7	2	Vibrator	€ 27.60
8	2	Buzzer	€ 9.14
9	2	Accelerometer, Gyroscope	€ 16.08
10	1	Watch Band	€ 10

Backup components will be ordered in case of malfunctions as shown in the Quantity column in the table.

Delivery of the components may cost from € 0 – 15.
The highest predicted price for all the components including the backup components is €173.87. The labor costs will be nothing because the project is being carried out by students. There will be no special equipment that is at any cost. All equipment will be free and open source.

3.2.3 Physical properties

This subchapter outlines the key physical properties which will be considered during the process of designing and manufacturing the smartwatch. In the table below the most important properties are considered to ensure user comfort, durability, and ease of use.

Property No	*Physical Property*	*Description*
1	Size	Compact and wearable, designed to comfortably fit on the wrist.
2	Weight (maximum mass)	Lightweight for comfortable all-day wear.
3	Shape	a square or circular design for a comfortable wear which will be printed using a 3D printer.
4	Material Composition	Durable and non-allergic materials for comfortable wear.
5	Color	Blue which is associated with trust and reliability
6	Display	OLED or similar display technology for clear visibility and low power consumption.
7	Water Resistance	Resistant to water and sweat to withstand daily wear and activities.
8	Battery Life	Reasonable lasting battery without frequent recharging.
9	Connectivity	Wi-Fi and Bluetooth capabilities for communication with other devices and networks.
10	Sensors	Gyroscope for fall detection, location tracker, Heartbeat Sensor, Temperature Sensor.
11	Compatibility	Compatibility with iOS and Android smartphones for app integration.
12	Charging Method	Standard Mini USB charging.
13	Alert Mechanisms	Vibration and audible alerts for notifications and reminders.
14	Input Methods	Physical buttons.
15	Location Tracking	Integrated location tracking module for accurate location tracking.
16	Panic Button	Physical button for triggering emergency alerts.

3.2.4 Environmental properties

This subchapter outlines the key environmental properties to be considered during the process of designing and manufacturing the smartwatch. In the table below the most important environmental properties considered, which include storage temperature, vibration limits, humidity, and Electromagnetic compatibility. By following these environmental standards, a safe and reliable solution for managing medication schedule can be achieved.

Property No	***Environmental Property***	
1	Storage Temperature	-20°C to 60°C (-4°F to 140°F)
2	Operating Temperature	0°C to 40°C (32°F to 104°F)
3	Vibration Limits	Up to 2g (20 m/s^2) in operational conditions
4	Humidity	Up to 95% RH (non-condensing)
5	EMC (Electromagnetic Compatibility)	Compliant with FCC and CE regulations

3.2.5 General design requirements

No.	***Design Requirements***	***Explanation***
1	User friendly Device	The system should be easy to use as elderly users have difficulty with technology.
2	Reliability	The system should be reliable in delivering the medication reminders in the exact time and sensors should always work.
3	Customizable	The system should allow users to add new medications alerts and change schedules.
4	Notification System	The system should have a sound alert to inform the user.
5	Battery Life	The system should be able to last for a long time without recharging.
6	Portable Design	The device should be light weight easy to carry around.
7	Sensors	The device should have sensors for fall detection, heart rate, and more.
8	Location	The device should have a location tracking device to provide the location of the user if an emergency were to happen.
9	Database	The system should have a place to store all user's data.

3.2.6 Mechanical design

The watch will be designed to have a low centre of mass and a wide footprint, these factors mean that the watch will remain comfortable during everyday use, the low COM will prevent the corners of the watch from digging in and the wide base will apply the pressure more evenly.

No.	***Mechanical design requirements***	***Explanation***
1	Low centre of mass	Low COM will mean there's less pressure applied to the edges of the watch thus wrist during regular usage
2	Wide footprint	A wide footprint will more evenly apply pressure, so pressure sores and discomfort are less likely
3	Durable Material for housing	The more durable the material the less likely it is to break, as the watch is designed to fall Hi durability is a must
4	Low profile	The lower the profile of the device the less likely it is to be damaged from random bumps and scratches
5	UV stable housing	The housing should be UV resistant to not degrade from sun exposure over time

3.2.7 Electrical and electronic design

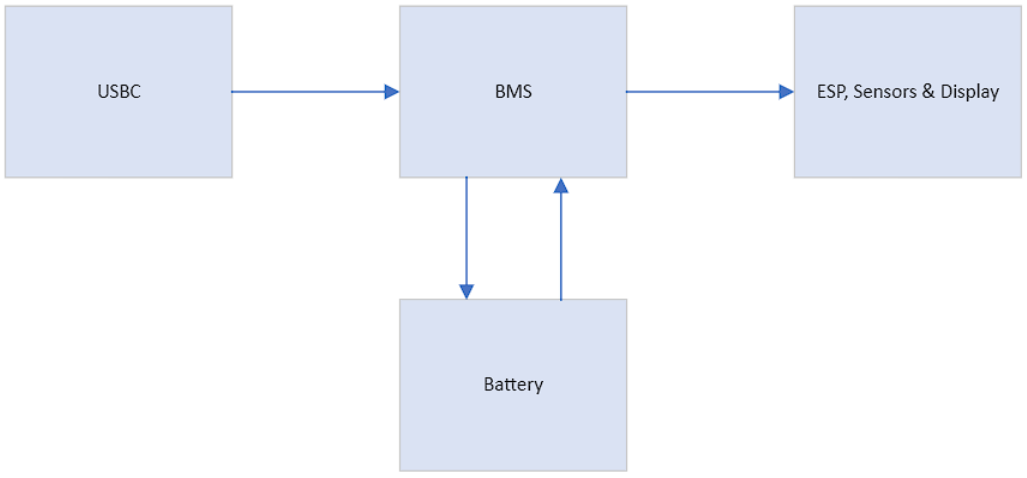

Figure 8 - Electrical design overview.

Electrical Design:

No.	***Electrical design***	***Explanation***

1	Small lightweight battery	A small battery will remove weight from the device and reduce the max size of the device,
2	Charging circuitry	Integrated charging circuitry will allow users to simply plug in their watch rather than remove the battery for charging
3	(BMS) Battery Management circuitry	Integrated battery protection will allow users to charge from any USB C cable without worrying about over charge or thermal problems

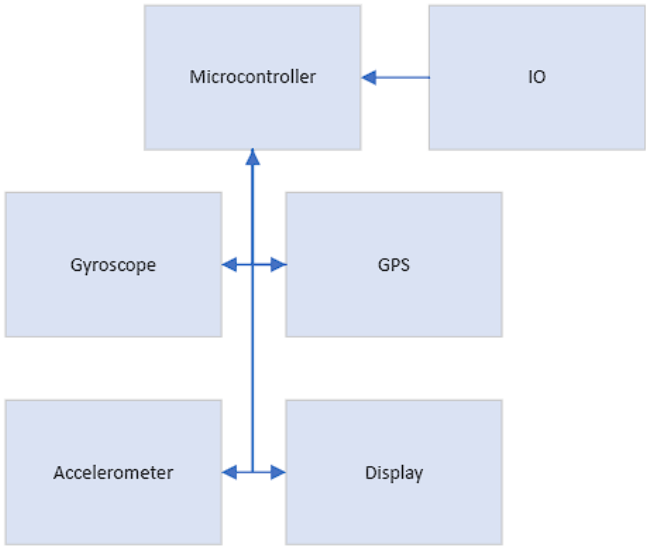

Figure 9 - Electronic design overview.

Electronic Design:

No.	***Electronic design***	***Explanation***
1	Sensors (Gyroscope, accelerometer)	Sensors like these will be used to detect a fall
2	GPS	A GPS module will be used to take the location of the user and send it to the emergency contacts
3	Display	The display will show the time, cancel emergency contact and medication notification
4	Microcontroller	The device will use a microcontroller with built in Bluetooth and Wi-Fi capabilities saving space and allowing for extra capabilities

3.2.8 Software design requirements

Programming Language and Operating Systems

The system will be developed using languages like C++, C, C#, or Java Script. It will be compatible with all operating systems such as, android, iOS, and windows as it will be a website.

Programming the device itself will be done using embedded C and C++. Because the team has previous experience utilizing the language.

Implementation Proposal

The system will have a website developed by CSS as the frontend. The backend could be done by many languages such as C++. A database will be created to store user data and the team will use Microsoft SQL Server for that. Notifications will be on the device itself.

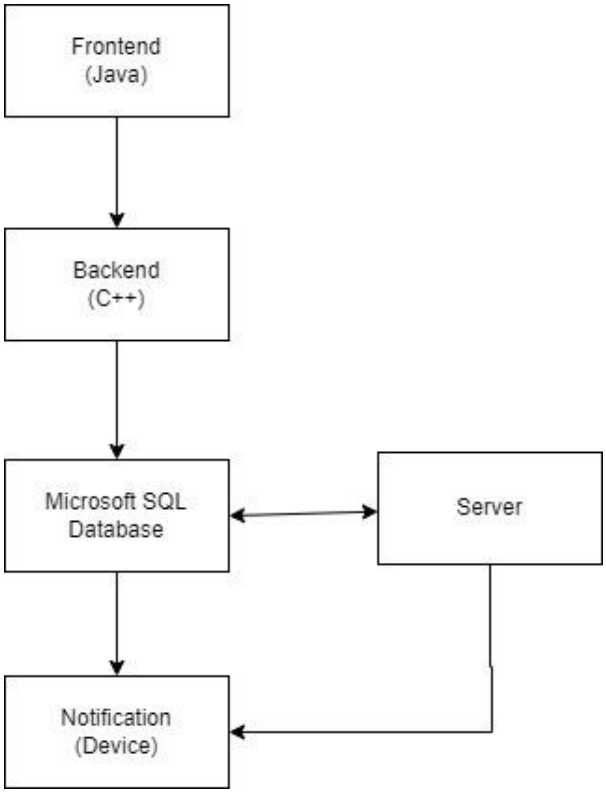

Figure 10 Software Flowchart

3.2.9 Production and assembly

Number	***Description***
1	Limited production (1-2 prototypes will be produced)
2	Assembled at Saxion Enschede
3	Components sourced from partners of Saxion
4	Production time 1-2 weeks

3.2.10 Reliability

Number	Description
1	The system should have an MTBF of at least 5000 hours.
2	The medication reminders should be on time.
3	The devices sensors should function properly.
4	Location tracking should provide the exact location.
5	The panic button on the safety device should work properly.
6	The device should be durable to handle falls.

3.2.11 Maintainability

Number	Description
1	The MTTR of the system should be between 3-7h
2	Heavy components like the battery should be glued in place
3	Display should be easily removable
4	The housing should come apart nondestructively
5	Strap should be user replaceable
6	Mainboard won't be repairable due to water resistant coating

4- Quality assurance Provisions

4.1 Verification definition

This chapter provides an overview of the specific goals and purposes of verification tests and analyses for both the Automated Medication Reminder System and the Personal Safety Device, ensuring that each system's functionality functions properly.

The progression of this chapter:

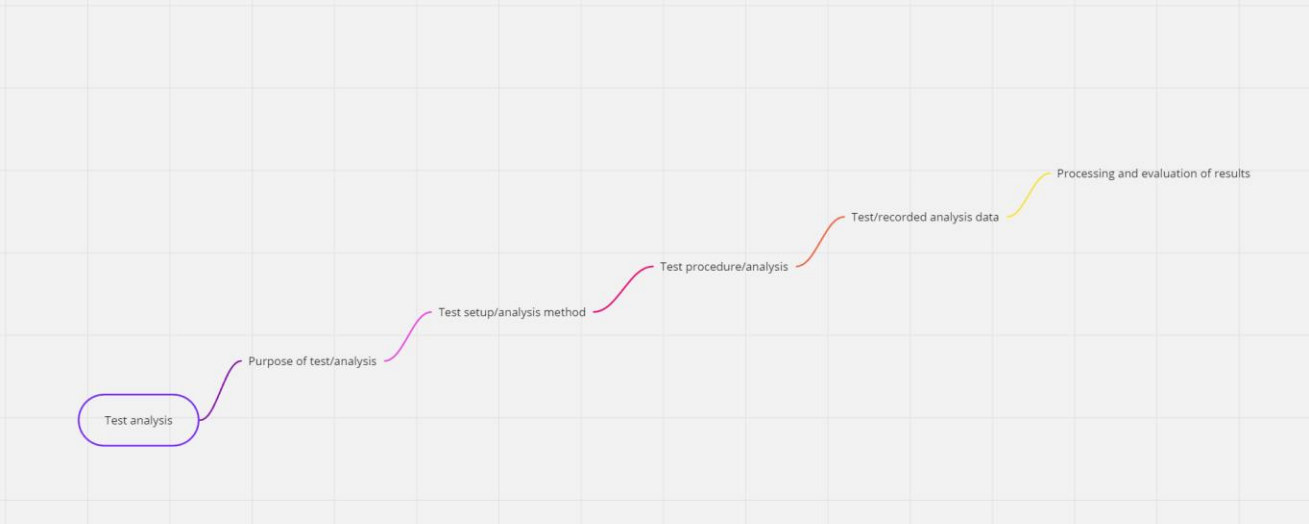

Figure 11 – Test control chapters.

4.2 Verification setup 1: control

4.2.1 Purpose of test/analysis

The goal of this test is to verify the functionality and reliability of the control system within the device. The test aims to ensure that the device responds correctly to user inputs and performs its designated functions without fail.

Requirements to test/analyse:

- Response time from input to action
- Accuracy of executing command sequences
- Stability of the control system under various conditions
- Recovery of the control system from error states

4.2.2 Test setup/analysis method

This subchapter shows the setup or analysis tests that needs to be done to ensure a reliable control unit.

Setup tests needed:

- **Input simulation unit:** emulating user's inputs with the device. ***Instruments***: not needed.
- **Output debugging tools:** measuring the device's reactions and comparing it with real life calculations. ***Instruments***: Oscilloscope and real-time debugging software such as GDB can help measuring the device reaction.
- **Environmental test:** simulating different physical conditions the device may encounter. ***Instruments***: not needed.
- **Error injection:** deliberately initiating faults and observing the system's handling capabilities.
  Instruments: Communication tools such as UART, SPI, or I2C can be used as an instrument to help observing the system error handling.
- **Stress test:** putting the device through high load of conditions to test the robustness of the control system. ***Instruments***: not needed.
- **Performance Analysis:** measuring the response times and accuracy of the control system under different scenarios. ***Instruments***: Oscilloscope can be used to measure response time and accuracy.

4.2.3 Test procedure/analysis

Medication Schedule Management

1. Medication Schedule Management
    - Procedure:
        - Input medication schedules through the mobile app with varying dosage times and frequencies.
        - Verify customization options by testing different dosage schedules and frequency settings.
        - Change the varying dosage times and frequencies.
        - Remove the schedules.

2. Reminder notifications
    - Procedure:

- Test to see if the system accurately sends notifications to the user's phone.
- Ensure that the reminder is sent in advance and has the correct amount specified.

Personal Safety Device

1. Emergency activation
    - Procedure:
        - Activate the panic button and see if the predetermined contacts/monitoring services are alerted.
        - Assess the accuracy and reliability of location information included in emergency alerts.

2. Fall detection
    - Procedure:
        - Perform controlled falls to test if the function goes off correctly.
        - Evaluate the accuracy and sensitivity of the fall detection algorithm.
        - Verify the automatic initiation of emergency protocols upon fall detection.
        - Verify that the cancelation of the emergency protocols works, in case of a false alarm.
3. Location tracking
    - Procedure:
        - Move the device in various locations and environment conditions to assess the accuracy of the GPS tracking.
        - Test real-time transmission of location data to chosen contacts or monitoring service.

4.2.4 Test/recorded analysis data

Medication Schedule Management

- Recorded data:
    - Sample medication schedules input by users.
    - Timestamps, and screenshots of message tests.
    - Evaluate GPS tracking performance in different environments for reliability.

- Recorded data:
    - Activation timestamps and location data from panic button simulations.

- Results of fall detection tests, including detected events, false alarms, and how the system responded to those false alarms.
- GPS location coordinates and transmission timestamps during tracking tests.

4.2.5 Processing and evaluation of results

The following table will explain the evaluation of the results.

Medication Reminder System:

No.	Requirements	Test Setup/Preconditions	Steps to perform the test	Evaluation of results.
1	The system should provide medication reminders based on the user's medication schedule.	Ensure the medication Reminder System is installed and configured.	1. Set up multiple medication schedules with different medications and dosages.	Reminders are received at the specified times for each medication schedule.
2	The reminders/notifications will be customized though an app.	Ensure that the app is properly installed.	1. Customize medication reminders/notifications settings through the app.	Customized reminders are accurately reflected on the device.
3	Users should be able to input their medication details including dosage and the time to take the medications.	Ensure the user has access to the Medication reminder app.	1. Input medication details, including dosage and schedule, into the system interface.	Medication details are successfully stored and displayed in the system.

Fall Detection and Alert System for Elliptical Seizures:

No.	Requirements	Test Setup/Preconditions	Steps to perform the test	Result for test success
1	The device will be in the form factor of a portable watch.	Integrate all components of the watch and ensure it is powered and configured.	1. Inspect the device to confirm it resembles a portable watch.	The device physically resembles a portable watch and can be comfortably worn on the wrist.
2	The device should automatically detect elliptical seizures and trigger an emergency alert system though a fall detection system.	Ensure the device is connected and the fall detection system is configured and ready to go.	1. Simulate elliptical seizure motion to trigger the fall detection system.	The device successfully detects a fall and sends the emergency message
3	The device should send the user's location with a GPS module integrated in the device through Wi-Fi to a contact or control center in case of emergency or a fall.	Ensure the device has a functioning GPS module and is connected to Wi-Fi.	1. Simulate a fall and verify that the device sends the user's location to the emergency contact.	The device successfully sends the user's location to the emergency contact.
4	An emergency button should be implemented in the safety device.	Ensure the emergency button is easily accessible on the device.	1. Press the emergency button to activate the emergency alert system.	Pressing the emergency button triggers the emergency alert system which sends the user's location to the emergency contact.
5	The device must detect every fall and ask for user input to decipher if it's a false alarm or if the emergency contacts need to be notified.	Ensure that the device is configured to detect falls accurately.	1. Simulate falls of varying types.	The device detect all falls and asks the user to input if the fall is false, distinguishing between false falls and genuine ones that needs emergency.