PRIVATE HIGHER SCHOOL OF ENGINEERING AND TECHNOLOGY

MAJOR: ELECTROMECHANICAL

ENGINEERING SPECIALIZATION:

MECHATRONICS

Intelligent Medical Monitoring System for Preventive Patient Care

Prepared by:

HANI KHEDHIRI

OMAR MEJRI

GHASSEN BEN SALEM

YAHIA JBELI

ALA EDDINE CHIBOUNI

AYMEN BADEREDDINE

MAHJOUB HENCHI

Supervised by: **Professor Imen Saidi**

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Technical Domain

This project focuses on intelligent embedded systems for preventive healthcare and medical telemonitoring.

It uses connected devices to measure and transmit real-time biometric data such as heart rate, temperature, and oxygen saturation.

The system provides continuous, automated, and non-intrusive monitoring, especially for elderly or vulnerable individuals.

Data is transmitted via wireless networks to allow remote access by caregivers or healthcare professionals.

Automated analysis detects abnormalities early, improving response time and patient safety.

The project supports digital medicine trends and smart home integration for preventive care.

It helps reduce hospital burden while enabling proactive, predictive healthcare.

Connected Devices Used

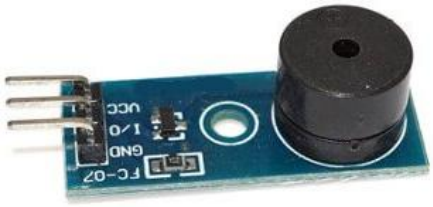
Heart Rate Sensor: Continuously monitors the heart's beats to detect irregularities, stress, fatigue, or potential cardiovascular conditions. It allows the system to identify abnormal patterns that may require attention.

Oxygen Saturation (SpO_2) Sensor: Measures blood oxygen levels to assess respiratory efficiency and overall oxygenation. This data is essential for detecting hypoxia or other respiratory issues early.

Intelligent Processing Unit: Functions as the system's "brain" by receiving, analyzing, and interpreting all sensor data in real time.

Display Screen: Provides immediate local visualization of measurements for the user, allowing them to monitor their own health status without delay.

Audible Alarm: Activates alerts when critical thresholds are exceeded, ensuring timely attention to potential health risks.



Wireless Communication: Transfers collected data securely to a remote platform using technologies like Wi-Fi, Bluetooth, or mobile networks. This ensures continuous monitoring even when the user is away from caregivers.

Web/Mobile Platform: Offers remote access to the data for family members, caregivers, or medical professionals. It enables real-time tracking, historical data analysis, and remote supervision, enhancing preventive care and early intervention.

This combination of devices creates an integrated, automated health monitoring ecosystem that is both **user-friendly and highly responsive**, providing continuous protection and peace of mind for users and their caregivers.

System Operation

The device begins by acquiring the user's physiological data using embedded biometric sensors.

The data is then sent to the processing unit, which applies algorithms to compare values with predefined medical thresholds.

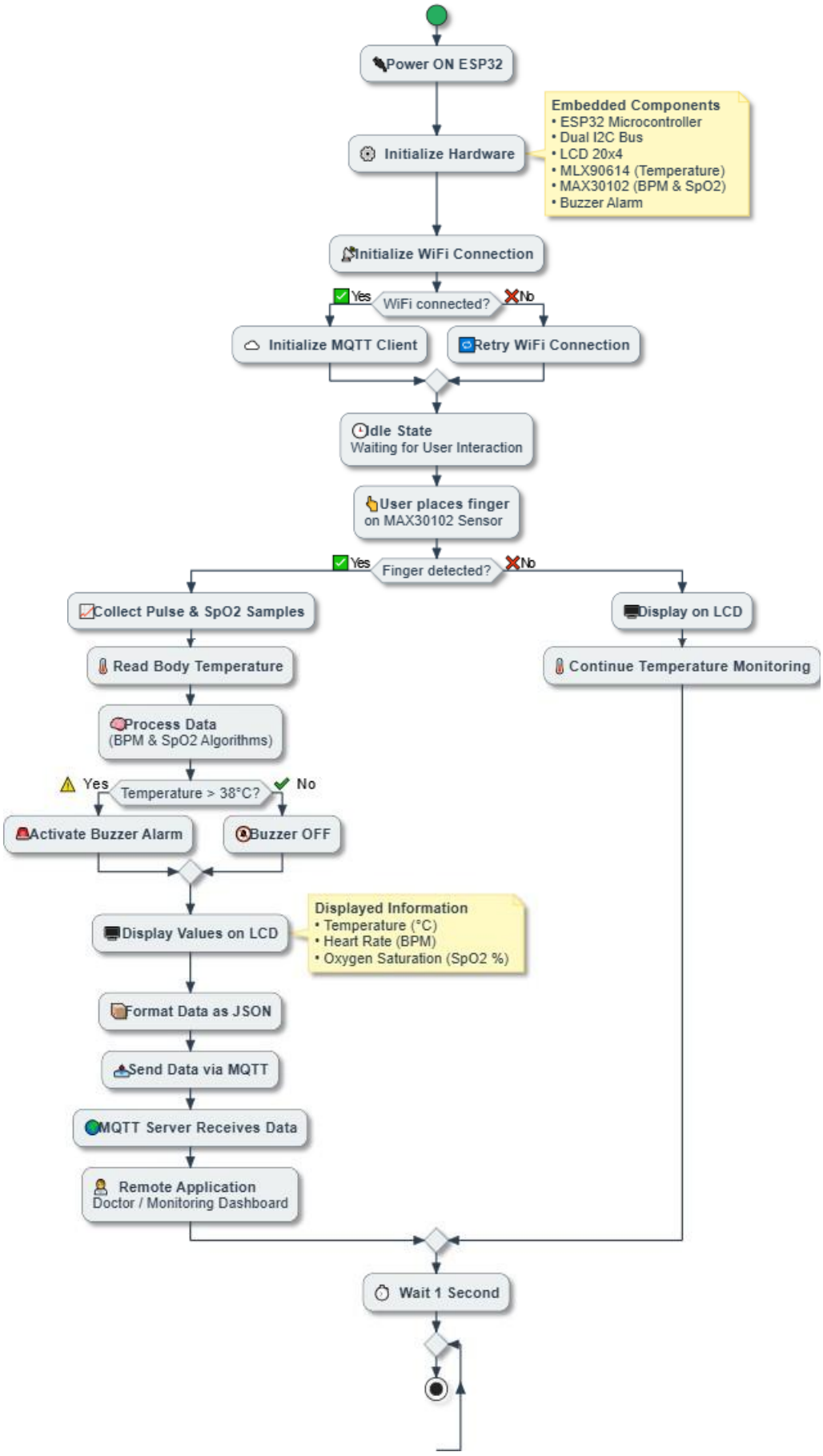
If any measurement exceeds a safe limit, a visual and audible alert is triggered immediately to notify the user or caregivers.

Simultaneously, the information is transmitted to a remote interface accessible via computer or smartphone.

This operation provides dual protection—local and remote—ensuring continuous and reliable monitoring.

ESP32 Health Care System

Smart Medical Monitoring - Global Project Flow



State of the Art

Existing health monitoring devices on the market generally focus on a single vital parameter**,** such as heart rate, temperature, or oxygen saturation, which limits their overall effectiveness in providing a comprehensive view of a person's health.

Many current solutions are designed primarily for hospital or clinical use and are not optimized for a home environment, making them less practical for everyday monitoring.

Some devices require advanced technical knowledge to operate or interpret, which poses a significant barrier for elderly users or those without technical expertise.

Available connected systems are often expensive and may rely on complex subscription models, limiting accessibility for average users.

There is also a notable lack of integration between measurement, data analysis, and alert generation, meaning that users or caregivers may not receive timely or actionable information.

Furthermore, most existing devices do not provide real-time, continuous monitoring, which reduces their ability to detect early anomalies or prevent health complications.

The user interfaces of many solutions are not intuitive or user-friendly, particularly for populations with reduced mobility, vision, or dexterity.

Many devices operate in isolation, without seamless communication to mobile apps, web platforms, or healthcare providers, limiting remote supervision and data sharing.

Some systems lack adaptability to individual health conditions, offering generic thresholds rather than personalized alerts.

Data security and privacy are often insufficiently addressed, raising concerns for users and healthcare professionals about sensitive health information.

Maintenance and calibration requirements in some devices are complex or frequent, discouraging consistent use.

Battery life and portability are often limited, restricting continuous monitoring throughout the day.

Integration with other smart home or IoT systems is rarely considered, reducing the potential for creating a comprehensive preventive care ecosystem.

Overall, there remains a significant unmet need for a health monitoring system that is integrated, simple, affordable, reliable, and suitable for domestic use.

Such a system would combine measurement, analysis, alerting, and remote supervision in a **user-**friendly and secure platform**,** addressing the limitations of current solutions while supporting preventive healthcare and independent living.

Intended Users & Beneficiaries

This innovative intelligent medical telemonitoring product targets a broad and rapidly growing market defined by specific needs in preventive healthcare and personal safety. Its primary audience consists of elderly people living at home who wish to maintain their independence while benefiting from a discreet and non-intrusive health safety net. It also addresses the needs of patients with chronic diseases—such as heart failure, diabetes, or respiratory conditions—who require regular monitoring of vital parameters to avoid complications and hospitalization.

The device is equally suited for individuals living alone, regardless of age, providing peace of mind against the risk of sudden illness or incidents without immediate assistance. For families and informal caregivers, it offers a practical remote-monitoring solution that transforms worry into actionable information. On an institutional level, it is well adapted to medical and social care facilities such as nursing homes and senior living residences, enabling optimized resident supervision and improved responsiveness of healthcare staff.

In the home healthcare sector, the product serves as a valuable tool for home nursing services and independent healthcare professionals—such as nurses and physiotherapists—by facilitating care coordination and patient follow-up between visits. General practitioners and

medical specialists (cardiologists, pulmonologists, etc.) can also use it for ambulatory monitoring, allowing more precise treatment adjustments and early detection of health deterioration.

The system is also attractive to insurance providers, mutual health organizations, and prevention agencies, offering a means to promote preventive medicine, reduce costly claims, and increase customer loyalty through value-added services. Companies operating in the Silver Economy and smart-home healthcare sectors can integrate it into their solutions to build comprehensive home care ecosystems. Finally, local authorities and hospitals may view it as a public-health tool to reduce emergency room congestion, streamline care pathways, and support secure aging-in-place programs.

Project Originality

The originality of this project lies in its **integrated, modular approach** to health monitoring, combining multiple biometric sensors—temperature, heart rate, and oxygen saturation—into a single system. Unlike many existing devices that focus on a single parameter, this project provides **continuous, real-time, and automated monitoring**.

Its **dual alert system**—local (audible/visual) and remote (web/mobile platform)—ensures comprehensive protection and immediate response.

The system is designed for **home use**, making it accessible, non-intrusive, and user-friendly for elderly or vulnerable individuals, without requiring technical expertise.

Additionally, its **modular and scalable architecture** allows for the easy addition of new sensors or features, supporting future adaptability and expansion.

Overall, the project stands out for offering a **complete, preventive healthcare solution** that integrates acquisition, processing, communication, and alerting in a single, reliable platform.

Project Overview

The project is based on an **intelligent modular architecture** divided into several functional blocks, each with a specific role.

The main blocks are:

1. **Acquisition Block:** Collects real-time biometric data via sensors such as temperature, heart rate, and oxygen saturation.

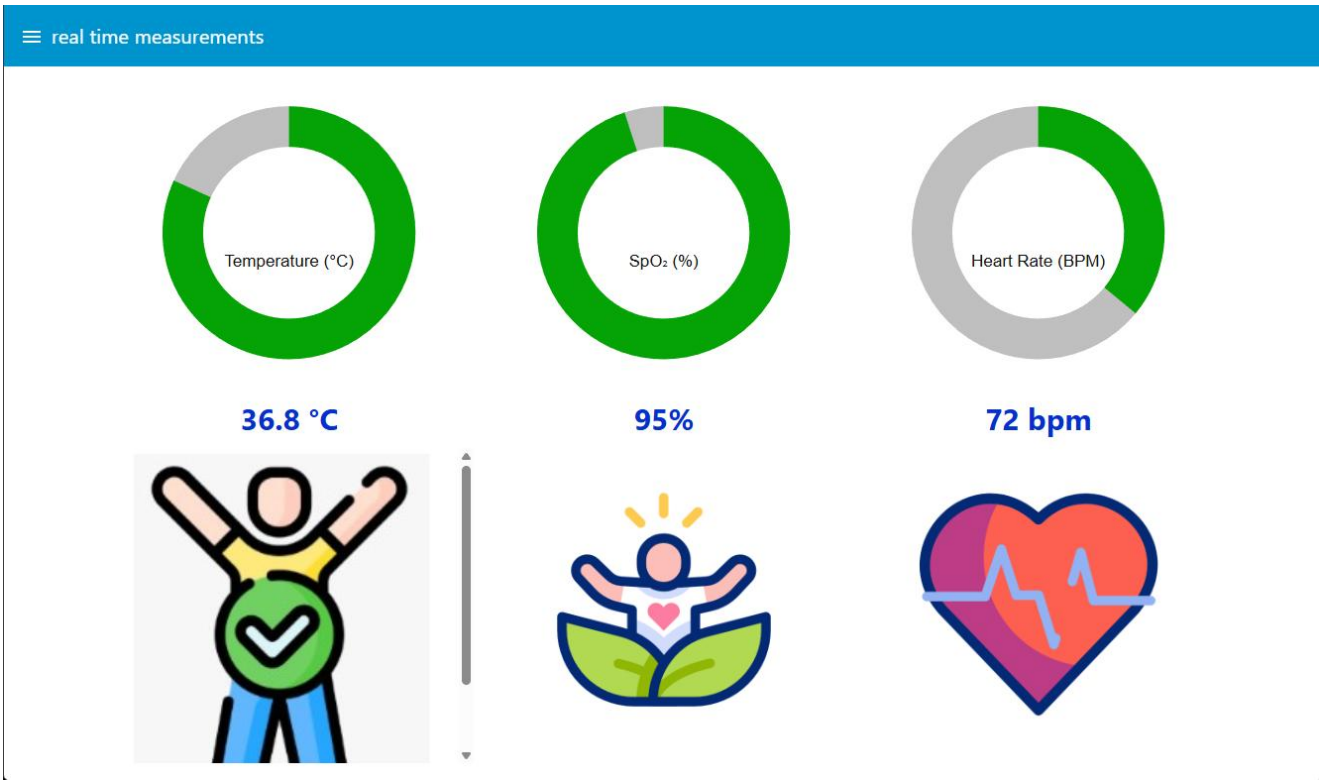
2. **Processing Block:** Analyzes data, detects anomalies, and generates insights using the intelligent processing unit.
3. **Communication Block:** Transmits data securely to web or mobile platforms for remote monitoring.
4. **Alert and Display Block:** Shows measurements locally and triggers alarms for critical conditions.

Architectural diagrams illustrate the **flow of data** from sensors to the user, showing how information is captured, processed, transmitted, and displayed.

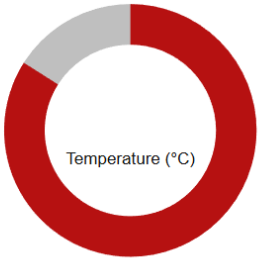
The **modular approach** allows easy addition of new features without affecting existing functions, ensuring scalability and maintainability.

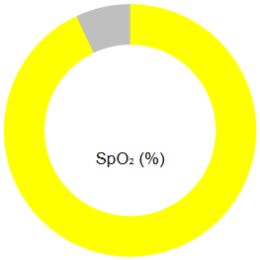
This organization highlights the system's **technical coherence** and supports efficient, real-time, home-based health monitoring.

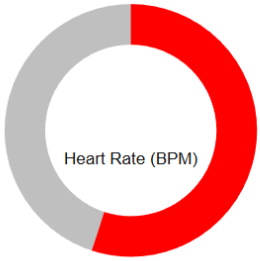
user interface:



real time measurements





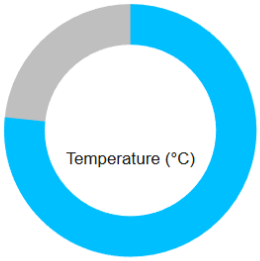


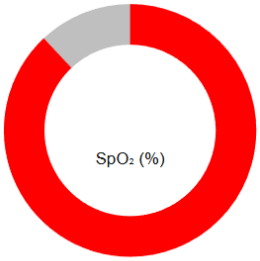
37.8 °C

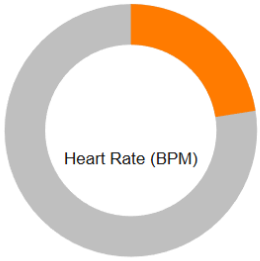
93%

110 bpm

real time measurements





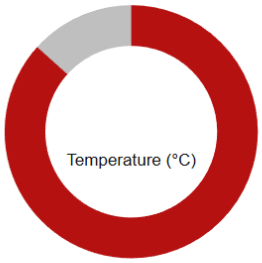


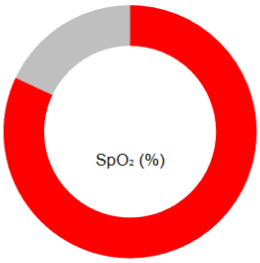
34.5 °C

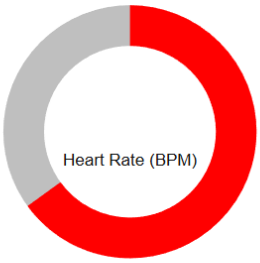
88%

45 bpm

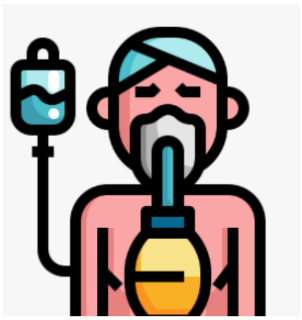
real time measurements



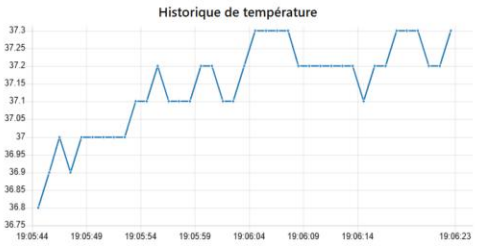




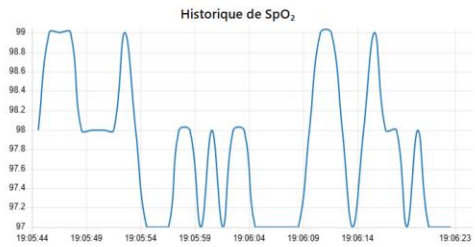
39 °C **82%** **130 bpm**



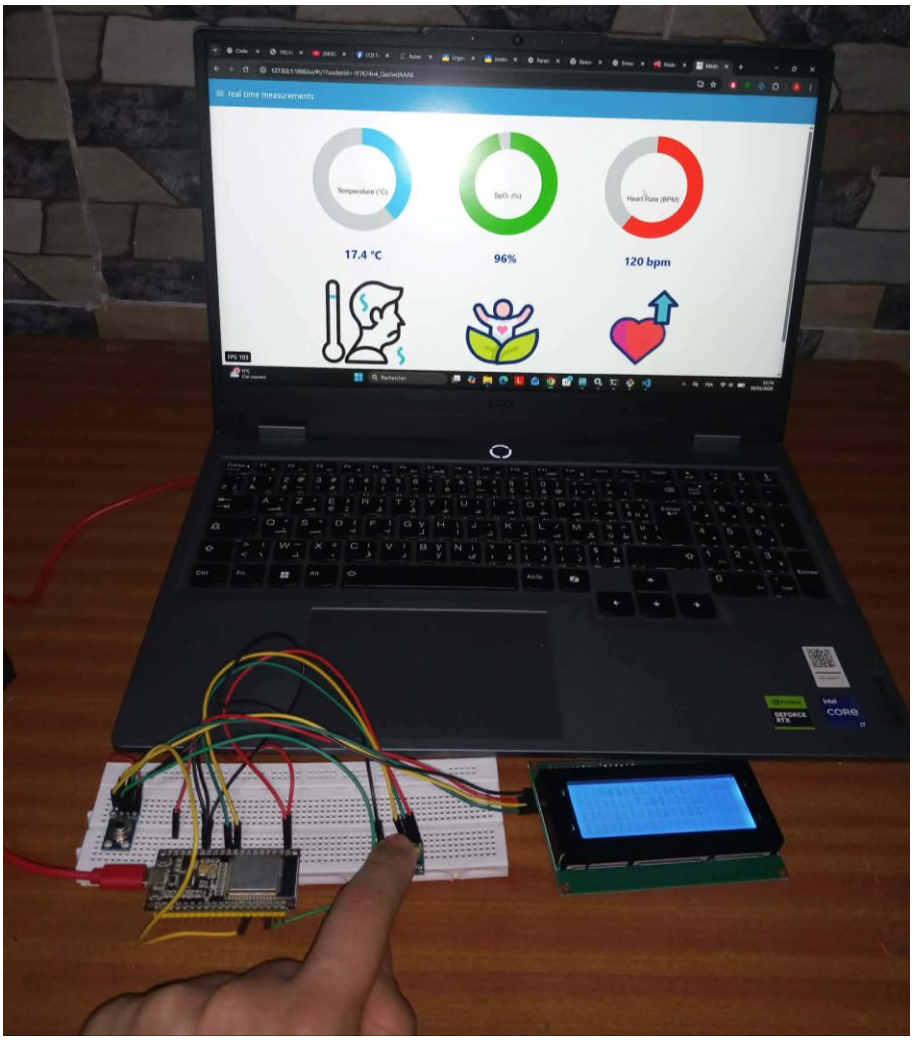
History



CLEAR



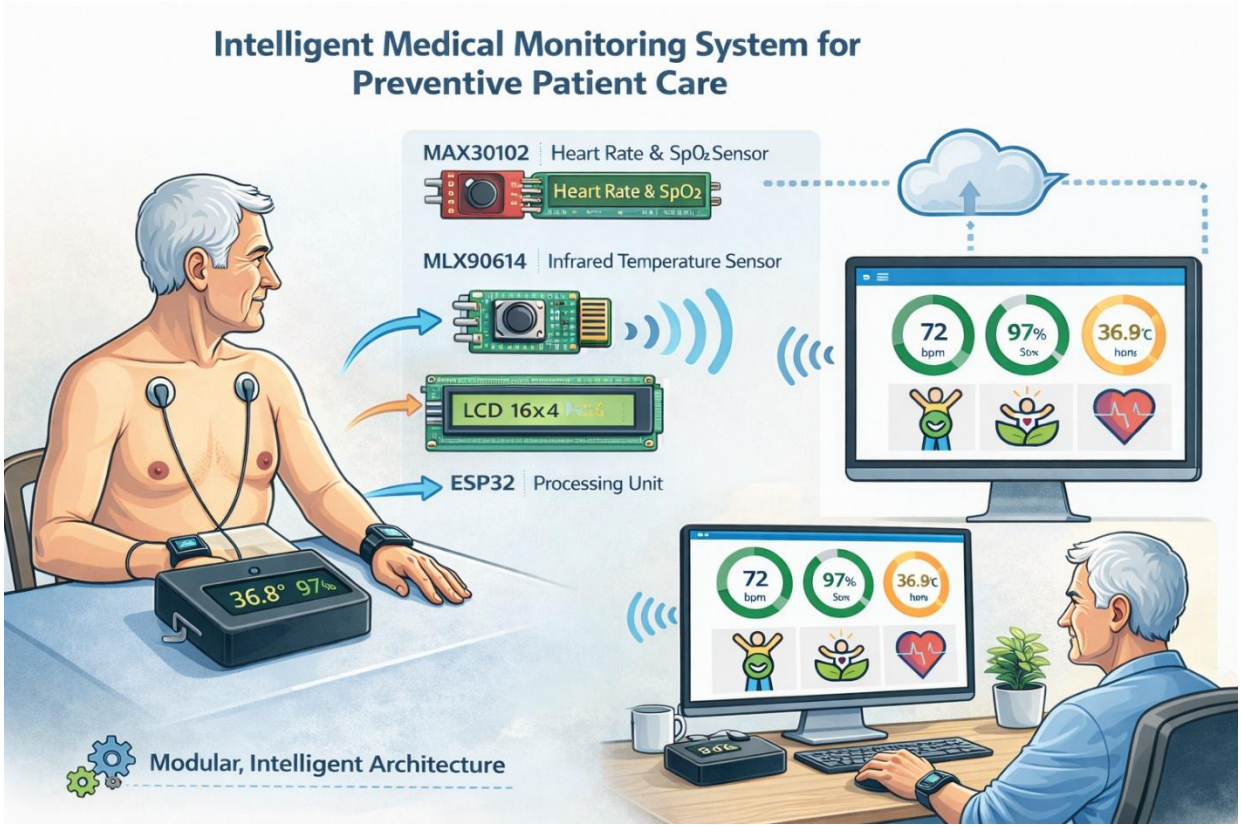
Setup:


real time measurements
17.4 °C
96%
120 bpm


Health Care
Temp: 18.55 C
HR:41 SPO2:66%
BPM:0

Use Cases

1. **Elderly Person Living Alone:**
   An elderly individual at home wears the monitoring device. The system continuously tracks heart rate, temperature, and oxygen saturation. If an abnormal value is detected, a **local alarm** alerts the user, while the data is simultaneously sent to family members or caregivers via the mobile app, allowing immediate assistance.
2. **Chronic Patient Monitoring:**
   A patient with a heart condition uses the system to track vital signs daily. The **processing unit analyzes trends** and sends alerts if any measurement exceeds safe limits. The healthcare provider can remotely review the data, adjust treatment, or schedule an intervention before a complication occurs.
3. **Preventive Health for Active Adults:**
   A working adult uses the device to monitor stress and fatigue levels throughout the day. The system detects unusual physiological changes, such as elevated heart rate or low oxygen saturation, and notifies the user via the **app**. This enables timely rest or medical consultation, preventing health deterioration.



Descriptive Summary

This project presents a smart, modular health monitoring system designed for preventive healthcare and remote medical supervision. It integrates multiple biometric sensors, including heart rate, temperature, and oxygen saturation, to provide real-time, continuous, and non-intrusive monitoring.

The system processes data locally using an intelligent processing unit, which compares measurements with predefined medical thresholds and triggers visual and audible alerts when abnormal values are detected. Simultaneously, data is transmitted securely to a web or mobile platform, allowing remote access for caregivers, family members, or healthcare professionals.

Its modular architecture ensures flexibility, enabling the addition of new sensors or functionalities without affecting existing operations. The project supports preventive and predictive healthcare, reduces hospital dependency, and contributes to the development of smart home environments focused on user safety and autonomy.

Overall, the system offers a reliable, accessible, and user-friendly solution for continuous health monitoring, early anomaly detection, and enhanced well-being