INSTITUT SUPERIEUR INFORMATIQUE ISI
المعهد العالي للإعلامية

UTM
جامعة تونس المنار
UNIVERSITÉ DE TUNIS EL MANAR

Higher Institute of Computer Science

Project Specification

Hospital Room and Patient Monitoring System

Based on ESP32

Students:

- Firas Kahlaoui
- Seifdine Ben Fradj
- Hamza Bargoug
- Ahmed Chaabane

Academic Year: 2025 – 2026

Contents

1 Context and Problem Statement

In hospital environments, continuous monitoring of patient vital signs and room conditions plays a critical role in improving healthcare quality and response time. However, the manual tracking of these parameters often leads to an increased workload and a higher risk of human error for healthcare professionals. This project proposes an ESP32-based IoT system equipped with sensors to collect patient and environmental data in real time and display it through a web-based dashboard. By empowering AI on the Cloud to handle data synthesis and reporting, the system addresses the urgent need to reduce the cognitive and administrative burden on medical staff, allowing them to focus more effectively on direct patient care.

2 Project Objectives

- Design a real-time monitoring system for a hospital room.
- Monitor the patient's heart rate.
- Measure room temperature and humidity.
- Make predictions using an AI model utilising collected data.
- Provide a web dashboard for data visualization and history tracking.
- Trigger alerts when abnormal conditions are detected.

3 Users

- **Medical Staff**: view patient data and receive alerts.
- **Administrator**: manage users, configure thresholds, and supervise the system.

4 Functional Requirements

- Monitoring and Data Acquisition
- Data Transmission and Storage
- AI prediction
- Web Dashboard
- Alerts and Notifications

5 Non-Functional Requirements

- **Availability**: the system shall operate continuously with network recovery mechanisms.
- **Reliability**: invalid or inconsistent data shall be detected and flagged.

- **Security**: secure authentication and encrypted communication (HTTPS).
- **Performance**: near real-time data updates based on sampling frequency.

6 System Architecture

6.1 Overview

- Sensor layer: heart rate, temperature, humidity, optional camera.
- Embedded layer: ESP32 for data acquisition and transmission.
- Server layer: API, database, and alert processing.
- IA layer: Make predictions using the collected data.
- Application layer: web dashboard for visualization and management.

6.2 Data Flow

1. Sensors send measurements to the ESP32.
2. ESP32 processes and transmits data to the server.
3. The server stores data and evaluates alert conditions.
4. A cloud server analyse data and generate report and predictions.
5. The dashboard retrieves and displays data and alerts.

7 Hardware Specifications

Component	**Description**
ESP32	Microcontroller with integrated Wi-Fi for data acquisition and communication.
Heart Rate Sensor	Pulse sensor or optical heart rate module.
Temperature and Humidity Sensor	Sensor such as DHT22 or equivalent.
Camera Module (Optional)	ESP32-CAM or compatible camera module.

8 Software Specifications

8.1 Embedded Software (ESP32)

- Sensor data acquisition.
- Wi-Fi connection management and reconnection.
- Error handling and diagnostic logging.

8.2 Backend Server

- Database management.
- Alert rules based on configurable thresholds.
- User authentication and access control.

8.3 Web Application

- Real-time monitoring page (values, sensor status, last update time).
- Historical visualization (charts and tables for selected periods).
- Alerts page (list, filters, and history).

8.4 AI model

- Determine environmental conditions using temperature and humidity data.
- Detect anomalies in the patient using heartbeat data.
- Generate daily reports.

9 Data Management

9.1 Collected Data

- Heart rate (BPM).
- Temperature (°C).
- Humidity (%).
- Blood Oxygen Saturation (SpO_2)

9.2 Data Retention Policy

- Data shall be stored for a defined retention period.
- Access to data shall be logged for security and traceability.

10 Testing and Validation

Test	**Objective**	**Success Criteria**
Heart rate acquisition	Validate BPM readings	Stable and realistic values
Temperature and humidity reading	Validate environmental data	Accurate and responsive values
Wi-Fi transmission	Validate data transfer	Data received without significant loss

Alert triggering	Validate threshold alerts	Alerts generated correctly
AI model inference	Validate AI-based analysis and assessement	Model outputs are consistent, within expected ranges, and match reference dataset labels with acceptable accuracy
Presence detection (optional)	Validate camera feature	Correct detection and alerting
End-to-end AI pipeline	Validate full data flow from sensors to AI output	Correct AI predictions generated from live sensor data without system failure

11 Deliverables

- ESP32 embedded source code.
- Backend API and database.
- Web dashboard application.
- AI models.
- Technical documentation (installation and user guide).
- Final report and demonstration.