Real-Time Temperature and Humidity Detection with ESP32

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Problem

Research labs need precise control of environmental conditions like temperature, humidity, pressure, and air quality to study microorganisms and the diseases they cause. Existing solutions are often costly and lack real-time control. This project develops a low-cost ESP32-based system that monitors and adjusts these conditions to create optimal environments for research, helping scientists better understand diseases and develop cures.

Project Objectives

- Develop an ESP32-based system to monitor temperature, humidity, pressure, and air quality in real time.
- Integrate sensors (e.g., DHT11, BMP280) for accurate environmental data collection.
- Implement automatic control mechanisms (e.g., fans, heaters) to regulate lab conditions.
- Ensure the system supports environmental stability for microorganism research.

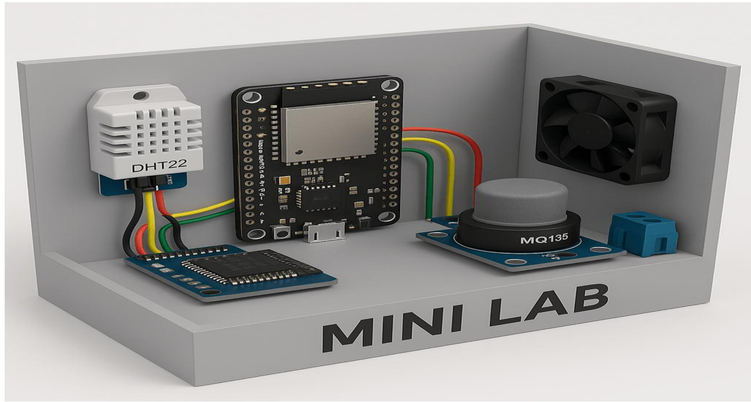
Project Requirements

- **ESP32 microcontroller** – for processing and communication.
- **DHT11 or DHT22 sensor** – for temperature and humidity.
- **BMP280 or BME280 sensor** – for pressure (and optionally, more accurate temp/humidity).
- **Relay module or motor driver** – to control fans, heaters, or other actuators.
- **Cooling fan / Heater / Humidifier** – for adjusting the environment.
- **Power supply** – to power the ESP32 and sensors reliably.
- **Wires, resistors, breadboard** – for circuit connections.

Target Users

Researches	Lab Technicians	System Developers
• Researches will use the system to study how microorganisms behave under different environments	• Technicians will monitor and maintain the system daily to ensure it runs smoothly	• Developers will configure , update and troubleshoot the system hardware and software

Project Design



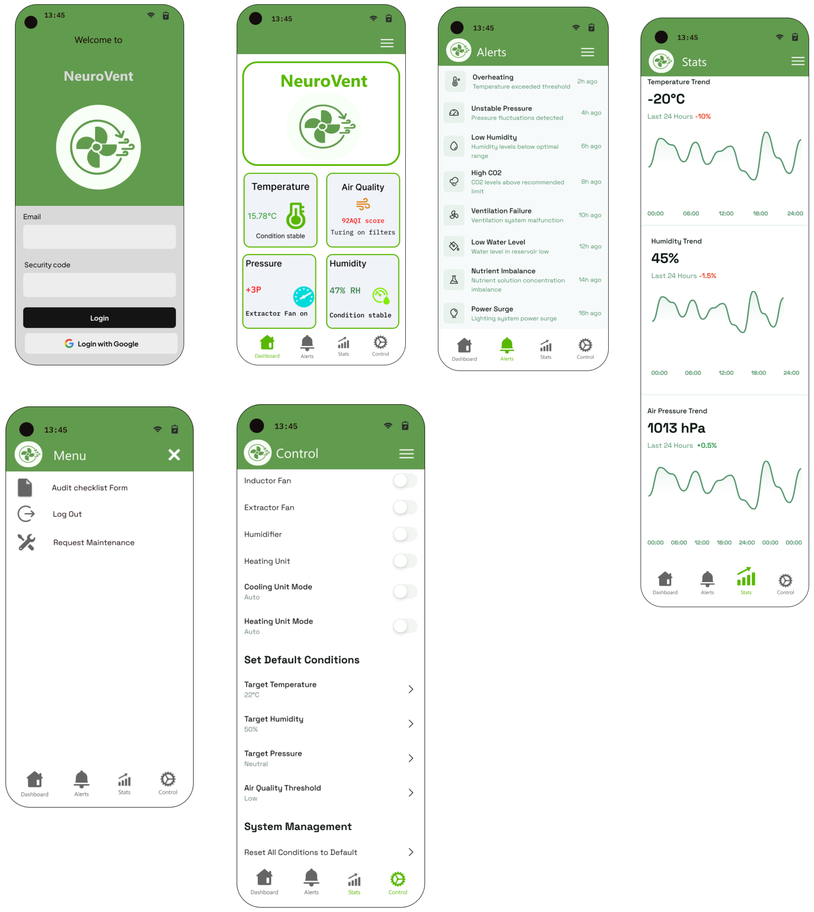
Key components

- **ESP32** – Controls sensors and system logic
- **DHT11 Sensor** – Measures temperature and humidity data
- **BMP280 Sensor** – Detects atmospheric pressure and altitude
- **Relay Module** – Switches fan or heater automatically
- **Fan / Heater** – Regulates lab temperature as needed
- **Power Supply** – Powers ESP32 and connected components
- **Arduino IDE** – Programs and uploads code to ESP32

Future Work

- **Add Remote Monitoring:**
  Implement a web or mobile app interface to allow researchers to monitor environmental conditions and control settings remotely via Wi-Fi or the internet.
- **Data Logging and Analysis:**
  Integrate cloud storage or local SD card logging for long-term data collection, enabling detailed analysis and trend prediction.
- **Expand Sensor Suite:**
  Add more advanced sensors for additional parameters like CO_2 levels, volatile organic compounds (VOCs), and light intensity.
- **AI-Based Environment Optimization:**
  Use machine learning algorithms to automatically adjust environmental conditions for optimal microorganism growth based on historical data.
- **Alert and Notification System:**
  Develop an alert system (SMS, email, or push notifications) to inform users if conditions go outside preset thresholds.
- **Power Efficiency Improvements:**
  Optimize system power consumption to enable battery operation for portable or remote lab setups.

Results



Conclusion

- The project successfully developed a low-cost, ESP32-based system for monitoring and controlling temperature, humidity, and pressure in a lab environment. It enables researchers to create stable conditions suitable for studying microorganisms and diseases. By automating environmental control, the system improves experimental accuracy, supports disease research, and lays a foundation for future enhancements like remote monitoring and data analysis.