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Smart IoT-Based Agriculture Monitoring and Protection System using ESP32

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ABSTRACT: Agriculture is a crucial sector that supports the livelihood of a large population. However, traditional farming methods suffer from inefficiencies such as excessive water usage, lack of monitoring, and crop damage due to environmental conditions and animals. This paper presents a Smart IoT-Based Agriculture Monitoring and Protection System using the ESP32 microcontroller.

The system integrates multiple sensors including soil moisture sensor, DHT11 temperature and humidity sensor, and ultrasonic sensor to continuously monitor environmental conditions. Based on sensor data, the system automatically controls irrigation through a water pump, maintains temperature using a fan, and provides protection against animals using an alert system. The ESP32 enables IoT functionality by hosting a web server that allows real-time monitoring of farm conditions.

The proposed system reduces human effort, improves water management, enhances crop safety, and provides a cost-effective solution for modern agriculture. Experimental results show reliable operation with efficient automation and quick response.

KEYWORDS: IoT, ESP32, Smart Agriculture, Automation, Sensors, Irrigation System.

I. INTRODUCTION

Agriculture is a fundamental sector that supports the economy and provides food for the growing population. However, traditional farming methods often depend on manual monitoring and irrigation, which can lead to inefficient use of water, time, and labor. With increasing environmental challenges and resource limitations, there is a strong need for smart and automated solutions in agriculture. The use of modern technologies like the Internet of Things (IoT) enables real-time monitoring and better decision-making, helping farmers improve productivity and reduce wastage.

This project presents a Smart IoT-Based Agriculture Monitoring and Protection System that integrates sensors and automation to enhance farming efficiency. The system uses a soil moisture sensor for automatic irrigation, a DHT11 sensor for monitoring temperature and humidity, and an ultrasonic sensor for detecting animals to protect crops. An ESP32 microcontroller processes the data and enables wireless communication, allowing users to monitor the system remotely through a web interface. Overall, the system reduces manual effort, conserves resources, and promotes smart and sustainable farming practices.

II. RELATED WORK

1. To develop an automated irrigation system using soil moisture sensing
 2. To monitor temperature and humidity continuously
 3. To detect animals using ultrasonic sensing
 4. To reduce human intervention in farming
 5. To provide real-time monitoring using IoT
 6. To improve crop productivity and safety
- To design a low-cost and efficient smart farming system.

III. BACKGROUND OF THE RESEARCH

Traditional farming relies heavily on human effort and lacks precision. Water is often wasted due to improper irrigation methods, and environmental factors are not continuously monitored.

Recent research in smart agriculture focuses on:

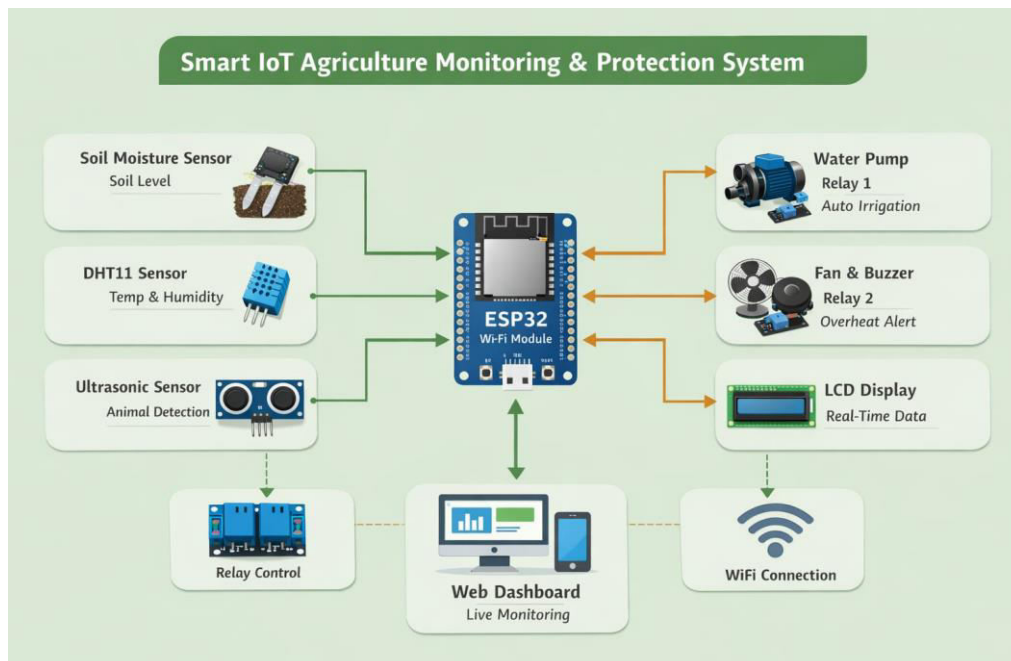
- Sensor-based monitoring systems
- Automated irrigation techniques
- Wireless communication systems

Biometric and IoT technologies have revolutionized industries, and agriculture is no exception. Microcontrollers like ESP32 provide powerful processing capabilities with built-in WiFi, making them ideal for IoT applications.

The use of sensors enables accurate data collection, while automation ensures timely actions, improving overall system efficiency.

IV. METHODOLOGY

BLOCK DIAGRAM & DESCRIPTION OF BLOCK DIAGRAM



The block diagram of the Smart IoT-Based Agriculture Monitoring and Protection System represents the overall structure and interaction between different components of the system. The ESP32 microcontroller acts as the central processing unit that controls and coordinates all system operations.

1. Input Section (Sensors)

The system uses multiple sensors to collect real-time environmental data:

- **Soil Moisture Sensor:**

This sensor measures the water content in the soil and provides an analog signal to the ESP32. The microcontroller converts this signal into percentage values to determine whether the soil is dry or wet.

- **DHT11 Sensor:**

It measures temperature and humidity of the surrounding environment. The sensor sends digital data to the ESP32, which is used to monitor climatic conditions.

- **Ultrasonic Sensor (HC-SR04):**

This sensor detects nearby objects (animals) by transmitting ultrasonic waves and receiving the reflected signals. The ESP32 calculates the distance based on the time delay of the echo signal.

2. Processing Unit (ESP32 Microcontroller)

The ESP32 acts as the brain of the system. It performs the following functions:

- Reads data from all sensors
- Processes and analyzes the sensor values
- Compares values with predefined threshold conditions
- Makes decisions based on programmed logic
- Controls output devices accordingly
- Hosts a web server for IoT-based monitoring

The ESP32's built-in WiFi module enables wireless communication, allowing users to access system data remotely through a web browser.

3. Output Section (Actuators & Display)

Based on the processed data, the ESP32 controls various output devices:

- **Relay Module:**

The relay acts as a switch to control high-power devices:

- Water pump (for irrigation)
- Fan (for temperature control)

- **Water Pump :**

Activated when soil moisture is below a certain threshold to irrigate crops automatically.

- **Fan:**

Turns ON when temperature exceeds the set limit to maintain optimal conditions.

- **Buzzer:**

Provides audio alerts in two conditions:

- High temperature (beep alert)
- Animal detection (continuous sound)

- **LCD Display (16×2 with I2C):**

Displays real-time data such as soil moisture, temperature, humidity, and system status. It also shows WiFi connection details and IP address.

4. IoT Communication Module

The ESP32 creates a WiFi access point or connects to an existing network. It hosts a web server that allows users to monitor system parameters in real time.

The web dashboard displays:

- Soil moisture level
- Temperature and humidity
- Distance (animal detection)
- Status of pump and fan

This enables remote monitoring without the need for physical presence in the field.

5. Power Supply Section

All components are powered using a regulated power supply (5V/12V). The power supply ensures stable operation of sensors, microcontroller, and actuators. Proper voltage regulation is important to avoid system malfunction.

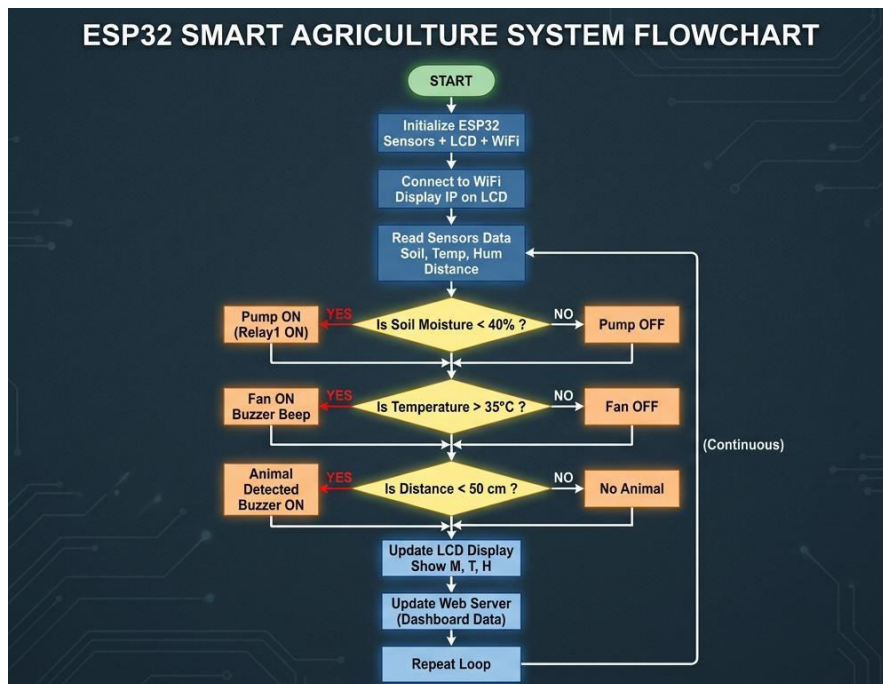
6. Overall System Operation

The complete system works in an integrated manner:

- Sensors collect environmental data
- ESP32 processes and analyzes data
- Output devices are controlled automatically
- LCD and web dashboard display real-time information

Thus, the system forms a closed-loop automated control system that improves efficiency, reduces manual effort, and enhances crop protection.

Flow Chart



The block diagram of the Smart IoT-Based Agriculture Monitoring and Protection System represents the overall structure and working flow of the system. The ESP32 microcontroller acts as the central unit that manages all operations by taking inputs from sensors, processing data, and controlling outputs.

1. Input Section (Sensors)

The system begins with input devices that continuously sense environmental parameters:

- Soil Moisture Sensor measures the water content in soil and sends analog data to ESP32.
- DHT11 Sensor provides temperature and humidity readings in digital form.
- Ultrasonic Sensor detects nearby objects or animals by calculating distance using echo signals.

These sensors form the first stage of the system where real-time data is collected.

2. Processing Section (ESP32 Microcontroller)

The ESP32 receives all sensor data and processes it according to programmed conditions. It compares sensor values with predefined thresholds and decides the appropriate action.

It also enables IoT functionality by connecting to WiFi and hosting a web server for remote monitoring.

3. Output Section (Control Devices)

Based on the processed data, the ESP32 controls output devices:

- Relay Module operates the water pump and fan
- Water Pump turns ON/OFF for irrigation
- Fan controls temperature
- Buzzer provides alerts for temperature and animal detection
- LCD Display shows real-time system data

4. IoT Monitoring Section

The ESP32 transmits data to a web dashboard via WiFi. Users can monitor all parameters such as moisture, temperature, humidity, and system status in real time.

5. Power Supply Section

A regulated power supply provides required voltage to all components ensuring stable operation.

Flow of Operation (Linked with Flowchart)

The working flow of the system, as represented in the flowchart, is integrated with the block diagram:

1. System Start (Power ON)
2. Initialization of ESP32 and Sensors
3. Sensor Data Collection (Moisture, Temperature, Distance)
4. Condition Checking
 - Moisture < Threshold → Pump ON
 - Temperature > Threshold → Fan + Buzzer ON
 - Distance < Limit → Buzzer ON
5. Control Output Devices
6. Display Data on LCD and Web Dashboard
7. Repeat Process Continuously (Loop)

This flow ensures continuous monitoring and automatic control without human intervention.

V. CONCLUSION

The Smart IoT-Based Agriculture Monitoring and Protection System provides an effective solution to modern farming challenges by integrating automation and real-time monitoring. The system successfully uses sensors to measure soil moisture, temperature, humidity, and detect animal intrusion, ensuring proper irrigation and crop safety. The ESP32 microcontroller efficiently processes the data and controls output devices like the water pump, fan, and buzzer, reducing the need for manual intervention and improving overall system efficiency. The results of the project show that the system is reliable, cost-effective, and capable of conserving water while increasing agricultural productivity. It also enables remote monitoring through IoT, making it user-friendly and practical for farmers. With future improvements such as mobile application integration and advanced sensors, the system can be further enhanced. Overall, this project promotes smart and sustainable agriculture by combining technology with traditional farming practices.

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