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IoT Based Irrigation & Fertilizer Dispensing System

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ABSTRACT: Agriculture in developing economies faces major challenges such as water scarcity, inefficient fertilizer utilization, and delayed identification of crop diseases. This paper presents an IoT-based Smart Irrigation and Fertilizer System using ESP32 that enables automated decision-making through real-time sensor data. Soil moisture sensors continuously monitor soil conditions and automatically control irrigation using a water pump. A color sensor is used to analyze leaf color variations for early detection of nutrient deficiency or plant disease, triggering a separate fertilizer pump only when required. The ESP32 microcontroller acts as the central unit, processing sensor data and communicating with a cloud platform via Wi-Fi for real-time monitoring and remote access. The proposed system improves resource utilization, reduces water and fertilizer wastage, and enhances crop productivity.

KEYWORDS: Smart Agriculture, Internet of Things (IoT), ESP32, Smart Irrigation, Fertilizer Automation, Precision Farming.

I. INTRODUCTION

This project presents an IoT-based smart irrigation and fertilizer spraying system for efficient crop management. It uses a soil moisture sensor to control drip irrigation and an RGB sensor to detect leaf color changes caused by nutrient deficiency or disease. An ESP32 microcontroller processes the sensor data and automatically controls irrigation and fertilizer pumps.Automatic gate valves ensure fertilizer is sprayed only on affected crop areas.The system reduces water wastage, fertilizer overuse, and manual effort while improving crop yield.

II. PROJECT DESCRIPTION

Agriculture productivity is significantly affected by improper nutrient management, fungal infections, and pest attacks on crops. Traditional methods of fertilizer and pesticide application involve uniform spraying over large areas, which Variations in leaf color are analyzed to identify nutrient deficiencies, fungal infections, and pest attacks, as these conditions cause distinct changes Min leaf pigmentation. Based on the detected color patterns, the system determines the affected region of the crop.

This enables localized spraying, ensuring that fertilizer or treatment solution is sprayed only on the specific leaf or crop region where the attack is detected, instead of spraying the entire field. This targeted approach minimizes chemical wastage and prevents unnecessary exposure of healthy plants.

The system integrates IoT technology to transmit sensor data to a cloud platform, allowing farmers to monitor crop health in real time through a mobile or web application. Alerts are generated when nutrient deficiency or disease symptoms are detected, enabling timely intervention. Automated control of pumps, sprayers, and gate valves reduces manual labor and ensures precise application of fertilizer and treatments.

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Overall, the proposed system improves resource efficiency, reduces operational costs, enhances crop health, and promotes sustainable farming practices by combining RGB-based crop health detection, IoT monitoring, and automated precision spraying.

III. METHODOLOGY

The system begins with initialization of the ESP32 controller and connected sensors, followed by continuous monitoring of leaf color and soil moisture to assess plant health and water requirements. The collected data is processed to identify pest-affected areas and determine the need for irrigation or fertilizer application. Based on this analysis, the controller activates relays, pumps, and automated gate valves to deliver water or spray fertilizer precisely to the required zones, such as a specific affected area. The integration of a mixing tank ensures proper blending of water and fertilizer before application. Additionally, the entire system is connected to an IoT platform for real-time monitoring, control, and manual override when necessary.

IV. HARDWARE COMPONENTS

1.ESP32 Microcontroller
The ESP32 acts as the main controller of the system. It receives data from the RGB sensors and controls the pumps, relays, and sprinkler system. It also enables IoT connectivity for monitoring and control.
2.RGB Color Sensors (3 Units)
These sensors detect the color of crop leaves in different areas. They identify changes in leaf color caused by pests, diseases, or nutrient deficiencies.
3.Sprinklers
Sprinklers are used to spray water or fertilizer on crops. They help distribute the liquid evenly over the targeted area.
4.Water Pump Motor
The water pump supplies water from the storage tank to the irrigation line for watering the crops.
5.Fertilizer Pump Motor
This pump transfers fertilizer from the fertilizer tanks to the sprinkler system for spraying on the crops.
6.Relays for Motor Control
Relays act as switches that allow the ESP32 to turn the water pump and fertilizer pump ON or OFF.

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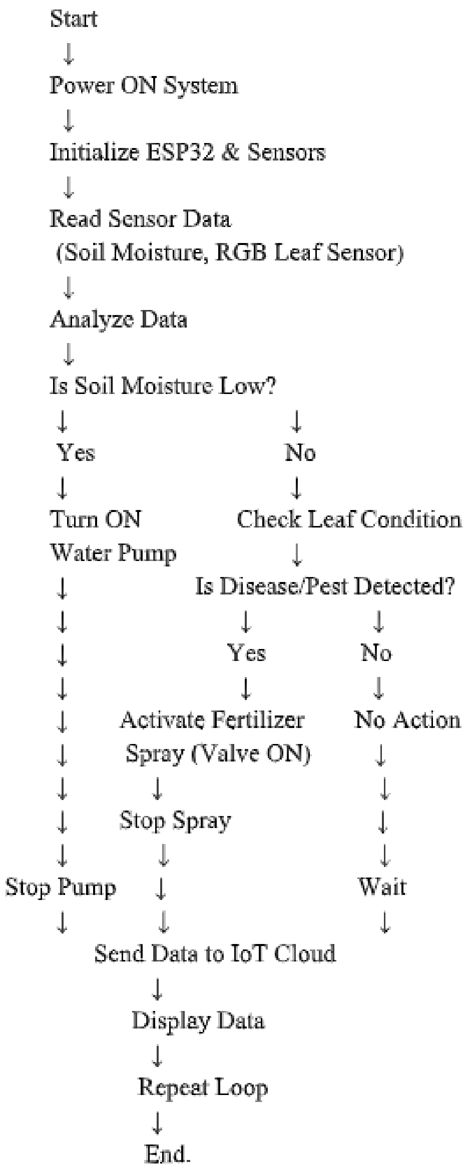
7.Sprinkler System
The sprinkler system distributes water and fertilizer to the crops and can rotate to cover specific areas in the field.
8.Power Supply Unit
The power supply provides the required electrical power to the ESP32, sensors, relays, and motors for proper operation.

V. SYSTEM ARCHITECTURE

The proposed system uses ESP32 as the main controller to manage irrigation and fertilizer dispensing operations. Three RGB color sensors are placed in different crop areas to detect leaf color variations and identify affected regions. The system includes three fertilizer storage tanks containing different solutions for pest, parasite, and predator control, which are mixed in a central storage tank before spraying. A separate water storage tank and irrigation line are used for regular watering of crops. Pump motors are used to transfer water and fertilizer from the tanks to the sprinkler system. A rotatable sprinkler mechanism directs the spray towards the detected area for targeted application. The entire system can also be monitored and controlled through a web-based IoT interface, allowing users to manually operate the irrigation and fertilizer system when required.

VI. FLOW DIAGRAM



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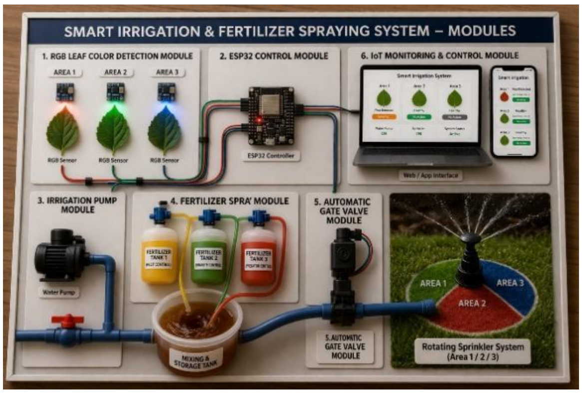
VI. MODULE DESCRIPTION

1. RGB Leaf Color Detection Module.
2. ESP32 Control Module.
3. Irrigation Pump Module.
4. Fertilizer Spray Module.
5. Automatic Gate Valve Module.
6. IoT Monitoring and Control Module.



VII. RESULT AND DISCUSSION

Results:

- The system successfully monitored soil moisture and leaf color (RGB values) in real-time.
- Automatic irrigation was triggered when soil moisture dropped below the threshold, ensuring optimal water usage.
- The RGB sensor effectively detected leaf color variations, indicating possible nutrient deficiency or pest attack.
- The fertilizer dispensing system accurately sprayed only the affected areas using the automated valve mechanism.
- Data was transmitted to the IoT platform, allowing remote monitoring and control through a mobile/web interface.
  The system reduced water wastage and excess fertilizer usage, improving efficiency.

Discussion

- The integration of ESP32 with sensors provided a reliable and low-cost solution for smart farming.
- RGB-based detection works well for visible changes but may have limitations under different lighting conditions.
- Targeted spraying improves crop health but requires precise calibration for accurate detection.
  IoT monitoring enhances decision-making, but performance depends on network connectivity.

Overall, the system supports precision agriculture, reduces manual labor, and increases productivity.

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VIII. CONCLUSION

The proposed IoT-based Irrigation and Fertilizer Dispensing System successfully integrates sensor technology, automation, and IoT monitoring to improve modern agricultural practices. By using soil moisture sensors and RGB-based leaf color detection, the system can intelligently control irrigation and apply fertilizer only in affected areas.

This approach reduces water consumption, minimizes fertilizer wastage, and enhances crop health and yield. The use of an ESP32 controller enables real-time data processing and remote monitoring through IoT platforms, making the system efficient and user-friendly.

Overall, the project demonstrates a cost-effective and scalable solution for precision agriculture, helping farmers achieve better productivity with reduced manual effort and resource usage.

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