Smart Farming -AI Powered Crop Yield Optimisation

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***Abstract*—Crop Health Monitoring is crucial for maximizing agricultural productivity. In this regard, the integration of machine learning has proven to be a game-changer. This project focuses on developing a system capable of producing high yield using machine learning, particularly by using IOT. Field Health Surveillance plays a key role in optimizing agricultural output. Monitoring the Health of Crops is essential for achieving high agricultural yields. Artificial intelligence (AI) has become a transformative tool in this field. This study proposes a machine learning-based system that detects and classifies leaf diseases, specifically an IOT for analysing soil parameters including PH, moisture, humidity and temperature. By using above parameters, the farmers can monitor the field conditions remotely by reading the collected values of sensors and actuators which are transmitted to the server using an Arduino microcontroller and wi-fi module. To predict health of the crop and to guide the farmers and sowing reasonable crops by deploying machine learning. This helps which crop has to be yielded based on the seasons or climatic conditions along with the yield produced with the available soil factors. Thus, the developed model can have better accuracy and crop prediction.**

***Index Terms*—Agriculture, Artificial Intelligence, Monitoring, Control, Prediction, Features, Convolutional Neural Network, Machine Learning.**

I. INTRODUCTION

Monitoring the health of the crop by using machine learning makes a ground breaking initiative by combining the agriculture with the technology, agriculture a primary pillar for a global sustenance by facing day to day challenges due to changing in the environmental conditions, pests and diseases. The intersection and agriculture and technology provides a solution to empower farmers with real-time insights. Implementing machine learning helps the project to focus on making greater changes in crop health assessment by leveraging, remote sensing, sensor networks and machine learning algorithms. The objective is to make farmers with comprehensive understandings of their fields, enabling timely interventions and efficient resource utilization.

II. PROCEDURE

The IoT-Based Smart Agriculture System follows a structured methodology to ensure efficient monitoring [1], automation, and remote accessibility for better farming practices. The methodology involves multiple steps, including sensor data collection, processing, decision- making, and IoT integration.
Below is a step-by-step breakdown of how the system works.

Fig: Block diagram

1. Sensor Data Collection: Various sensors measure soil moisture, temperature, humidity, and pH levels in the field. These readings are sent to the Arduino Uno microcontroller for processing.
2. Data Processing & Decision Making: The Arduino analyzes the sensor data and decides whether to turn ON or OFF the water pump based on soil moisture levels. If the soil is dry, irrigation starts automatically.

3. Automated Irrigation: The relay module controls the water pump, ensuring that crops get enough water. Once the soil moisture reaches the required level, the pump turns OFF automatically, saving water and energy.
4. IoT-Based Remote Monitoring: The system sends live data to IoT platforms (TELNET/ThingSpeak). Farmers can check real-time soil and climate conditions on their smart phones [12] or computers.
5. Alerts & Notifications: If conditions are critical (e.g., very dry soil, extreme temperatures, or incorrect pH levels), the system triggers a buzzer and sends alerts to the farmer's mobile for quick action.
6. Energy-Efficient Power Supply: The system runs on a stable 5V power supply and can also work with battery or solar power, making it suitable for remote areas.

III. METHODOLOGY

The algorithm defines the step-by-step process for how the IoT-Based Smart Agriculture [12] System functions. It ensures automated irrigation, real-time monitoring, and remote access through IoT.

Step-by-Step Algorithm:

1. Start the System
   - Power on the Arduino Uno and initialize all sensors (Soil Moisture, Temperature, Humidity, and pH).
   - Establish a connection with the Wi-Fi module for IoT communication.
2. Read Sensor Data
   - Measure soil moisture level using the LM324 sensor.
   - Read temperature from LM35 and humidity from DHT11.
   - Check soil pH level using the pH sensor.
3. Process the Data
   - Compare soil moisture value with the predefined threshold.
   - If the moisture level is low, irrigation is required.
   - If the temperature/humidity is abnormal, generate an alert.
   - If the pH level is out of range, suggest corrective action.
4. Control the Water Pump
   - If soil moisture is low:
     - Activate the relay module to turn ON the water pump.
   - If soil moisture reaches the threshold:
     - Turn OFF the water pump to prevent over-irrigation.
5. Display and Update Data
   - Show real-time sensor readings on the LCD display.
   - Send sensor data to TELNET or ThingSpeak IoT platforms for remote monitoring.
6. Alert Mechanism
   - If conditions are critical (dry soil, extreme temperature, improper pH levels):
     - Trigger buzzer alert in the field.
     - Send mobile notifications to the farmer via IoT.
7. Repeat the Process
   - Continuously monitor the field in a loop to keep the system updated.
   - If the power is turned off, the system resets and starts again.

IV. REQUIREMENTS

This Smart Agriculture System integrates various hardware and software components to automate irrigation, monitor environmental conditions, and provide real-time data to farmers. Below is a detailed explanation of each component used in the system.

1. Software Components

1.1 Arduino IDE

The Arduino IDE (Integrated Development Environment) is used for writing, compiling, and uploading code to the Arduino Uno microcontroller. It supports C/C++ programming and includes built-in libraries that help in interfacing with various sensors. The software provides an easy-to-use interface and allows real-time debugging of code before execution.

1.2 Proteus 7 (Embedded C)

Proteus 7 is used for simulating and testing the circuit before real-world implementation. It allows virtual testing of hardware connections, helping in debugging and optimizing the circuit before assembling it. The software provides real-time visualization of sensor data and actuator responses, ensuring efficient circuit functionality.

1.3 Express PCB

This software is used for designing Printed Circuit Boards (PCB) for the system. It provides schematic representations of hardware connections and helps in the physical implementation of the circuit layout. The use of Express PCB ensures a compact, efficient, and well-organized hardware setup.

1.4 TELNET / Thing Speak (IoT Cloud Platforms)

TELNET and Thing Speak are cloud-based platforms that allow farmers to monitor sensor data remotely. These platforms provide a graphical and text-based visualization of soil [6] moisture, temperature, humidity, and pH levels. Farmers can access this data from their smartphones or computers, allowing them to make informed decisions about irrigation and soil management.

2. Hardware Components

2.1 Arduino Uno (Microcontroller)

The Arduino Uno acts as the central processing unit of the system, interfacing with all the sensors and actuators. It reads real-time sensor data, processes it, and controls the irrigation system accordingly. The microcontroller is programmed using Arduino IDE and operates on 5V power.

2.2 Soil Moisture Sensor (LM324)

The soil moisture sensor measures the amount of water present in the soil [6]. It helps determine whether the field requires irrigation. If the moisture level drops below a certain threshold, the Arduino triggers the water pump to irrigate the crops automatically.

2.3 Temperature Sensor (LM35)

The LM35 temperature sensor monitors the environmental temperature. This data helps in understanding how climate conditions affect crop growth. The sensor provides accurate readings and is useful for maintaining optimal conditions for different crops.

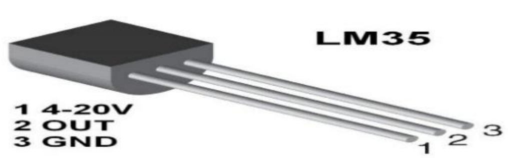


Fig. 2.3 Temperature Sensor (LM35)

2.4 Humidity Sensor (DHT11)

The DHT11 sensor measures humidity levels in the air. It helps in monitoring weather conditions, ensuring that crops receive the required moisture levels. The combination of temperature and humidity readings supports farmers in making better agricultural decisions.

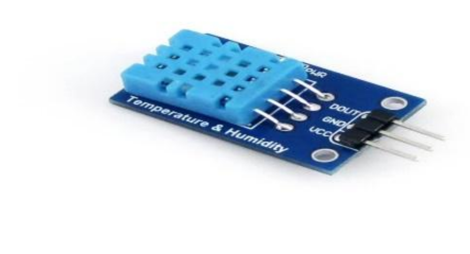


Fig. 2.4 Humidity Sensor (DHT11)

2.5 pH Sensor

The pH sensor monitors the acidity or alkalinity of the soil. Maintaining the right pH level is crucial for crop growth. If the pH level is too high or too low, corrective actions such as adding fertilizers or soil conditioners can be taken.

Fig. 2.5 pH Sensor

2.6 IR Sensor

The Infrared (IR) sensor detects the presence of objects. It is mainly used for security purposes or for detecting obstacles in automated farming systems.

Fig. 2.6 IR Sensor

2.7 Relay Module

The relay module is used to control the AC water pump based on the signals received from the

Arduino. It acts as a switch, turning the pump ON or OFF automatically based on soil moisture levels.

Fig. 2.7 Relay Module

2.8 AC Water Pump

The AC water pump is responsible for automatic irrigation. It receives signals from the relay module and pumps water to the field when soil moisture levels drop below the desired threshold.

2.9 Buzzer

The buzzer acts as an alert mechanism, notifying farmers about critical conditions such as low soil moisture, extreme temperatures, or high soil acidity.

Fig. 2.9 Buzzer

2.10 LCD Display

The LCD screen is used to display real-time sensor readings. It provides instant feedback to the farmer regarding soil moisture, temperature, humidity, and pH levels.

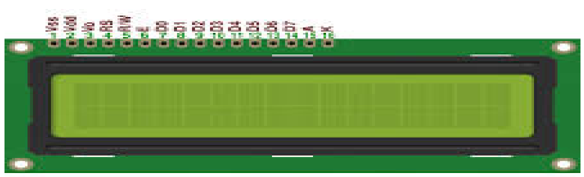


Fig. 2.10 LCD Display

2.11 Wi-Fi Module

The Wi-Fi module enables communication between the Arduino and IoT cloud platforms (TELNET / Thing Speak). This allows remote monitoring and control of the agricultural system.

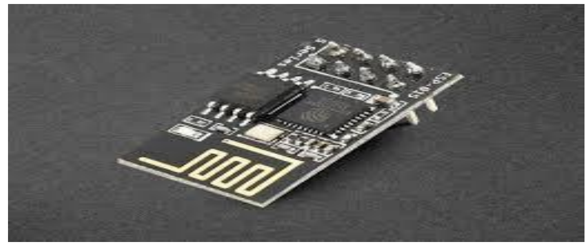


Fig. 2.11 Wi-Fi Module

2.12 Power Supply System

The power supply system ensures the smooth operation of all components. It includes:

- Step-Down Transformer – Converts high voltage AC to lower voltage.
- Voltage Regulator (7805) – Provides a stable 5V output for Arduino and sensors.

Rectifier & Filter Capacitor – Converts AC to DC for efficient power distribution.

V. HELPFUL HINTS

a. Automated Irrigation System – The system automatically controls the water pump based on soil moisture levels, ensuring crops receive the right amount of water. This prevents overwatering or underwatering, leading to better water management and increased crop yield.

b. Real-Time Environmental Monitoring – Sensors measure soil moisture, temperature, humidity, and pH levels, providing continuous updates on field conditions. This helps farmers maintain optimal growth conditions and improve productivity.

c. IoT-Based Remote Access – Farmers can monitor field conditions anytime, anywhere using IoT platforms like TELNET and ThingSpeak. Data is displayed on a mobile or web interface, allowing for informed decision-making without the need for physical presence.

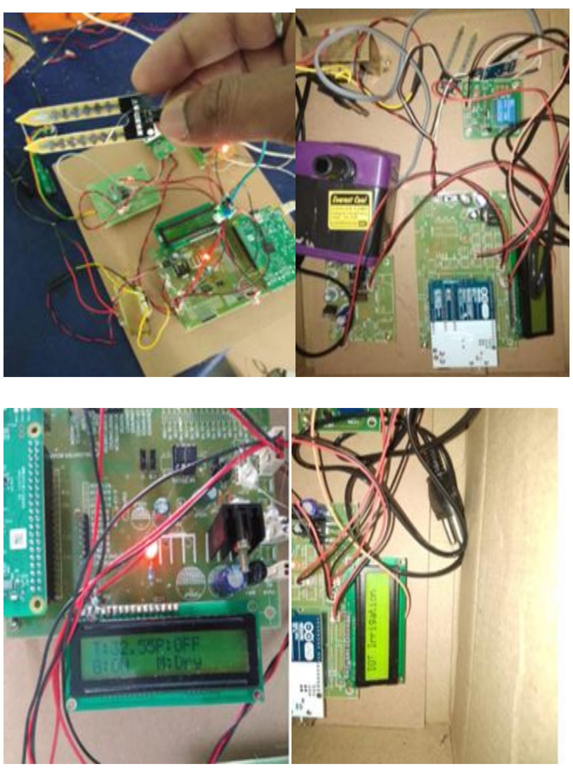
d. Smart Alert System – The system sends buzzer alerts or mobile notifications when critical conditions such as low moisture, extreme temperatures, or imbalanced pH are detected. This helps in taking immediate corrective actions, reducing crop damage.

e. Energy-Efficient & Cost-Effective – The system operates on a low-power Arduino microcontroller and can be powered by a battery or solar energy. It reduces labor costs by minimizing manual intervention, making it a budget-friendly solution for farmers.

f. Sustainable & Eco-Friendly – By optimizing water usage and monitoring soil conditions, the system promotes precision farming, prevents resource wastage, and enhances soil health. This leads to more sustainable and eco-friendly agricultural practices.

VI. RESULTS

The IoT-Based Smart Agriculture System was successfully implemented and tested. The system effectively monitored soil moisture, temperature, humidity, and pH levels in real-time. It automated irrigation by activating the water pump when the soil moisture level dropped below the set threshold and turned it off once the required level was reached. Data from sensors was accurately displayed on an LCD



screen and transmitted to TELNET/Thing Speak IoT platforms, enabling remote access. Additionally, the buzzer alert system and mobile notifications effectively notified farmers about critical conditions, ensuring timely action. The system proved to be energy-efficient, cost-effective, and reliable for modern farming.

VII. CONCLUSION

This Smart Agriculture System successfully integrates IoT, automation, and real-time monitoring to improve farming efficiency. By using sensor-based data collection and automated irrigation, the system reduces water wastage, minimizes manual labour, and enhances crop productivity. The incorporation of IoT platforms allows farmers to monitor field conditions remotely, making agriculture more data-driven and efficient. This project demonstrates that technology can significantly enhance traditional farming practices, ensuring sustainability and optimal resource utilization.

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