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Deep Learning Based Crop Health Monitoring Using IoT Sensors

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Abstract: *This paper proposes a smart crop-health monitoring system that combines Internet of Things (IoT) sensors with deep-learning-based image analysis. Crop health is affected by soil moisture, temperature, humidity, light and plant diseases. Periodic manual inspection may delay the identification of crop stress. The proposed approach collects field conditions through low-cost sensors and captures leaf images using a camera. Sensor readings and images are processed by a controller or computer. A trained deep learning model can analyse leaf images for visible symptoms, while sensor readings provide information about growing conditions. The system aims to display crop information and generate alerts to support timely crop-care decisions. This is an introductory project proposal; performance results will be added after implementation and testing.*

Keywords: Crop health monitoring, IoT, deep learning, plant disease detection, sensors, smart agriculture

I. INTRODUCTION

Agriculture is essential for food production and livelihoods. Crop growth and yield depend on environmental conditions and plant health. Low soil moisture, unsuitable temperature, excess humidity and plant diseases can reduce productivity. Early identification of these conditions helps farmers take corrective action. However, checking large fields manually requires time and effort. IoT sensors can collect field information continuously, while deep learning can identify visual patterns in plant images. Combining both technologies may provide a more complete view of crop conditions.

II. PROBLEM STATEMENT

Farmers may not identify early signs of crop stress or disease because field inspection is periodic and environmental readings are not always considered alongside visible plant symptoms. An affordable system is therefore proposed to collect relevant field parameters, analyse leaf images and communicate useful alerts.

III. OBJECTIVES

- Monitor soil moisture, temperature and humidity using IoT sensors.
- Capture leaf images for visual crop-health assessment.
- Explore a deep learning model to classify selected healthy and diseased leaf categories.
- Display sensor readings and image-analysis output through a simple interface.
- Generate alerts to support crop-care decisions.

IV. LITERATURE SURVEY

Mohanty, Hughes and Salathé [1] demonstrated the use of deep convolutional neural networks for image-based plant-disease detection. Kamilaris and Prenafeta-Boldú [2] reviewed deep learning applications in agriculture and discussed opportunities and challenges. Liakos et al. [3] reviewed machine-learning methods used in agriculture, including crop

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and soil monitoring. These studies provide a foundation for combining image analysis with field sensing. Real-world use still requires representative field images, sensor calibration and testing across different crop and weather conditions.

V. PROPOSED SYSTEM ARCHITECTURE

The proposed system has five stages: (i) data acquisition using sensors and a camera, (ii) data transfer through a microcontroller or computer, (iii) preprocessing of readings and images, (iv) deep-learning-based image classification and interpretation of sensor values, and (v) display of results and alerts.

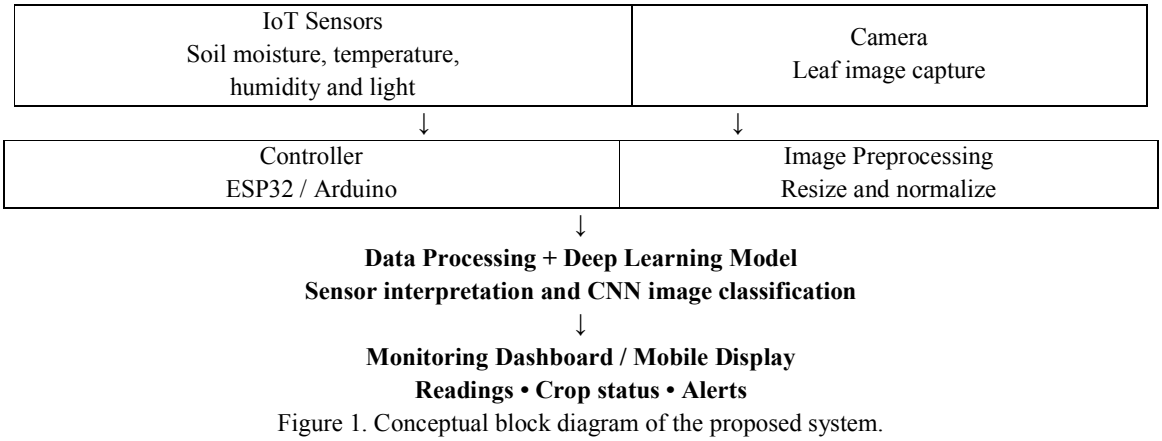


Figure 1. Conceptual block diagram of the proposed system.

VI. HARDWARE AND SOFTWARE REQUIREMENTS

Component	Purpose
ESP32 / Arduino Uno	Reads sensor data and manages communication.
Soil moisture sensor	Measures relative soil moisture.
DHT11 / DHT22	Measures temperature and humidity.
LDR (optional)	Measures relative light intensity.
Camera module / phone camera	Captures leaf images.
Power supply, wires, breadboard	Powers and connects the prototype.
Computer / laptop	Model training, testing and dashboard.

Software: Arduino IDE, Python, TensorFlow/Keras or PyTorch, OpenCV (optional), and a simple web or mobile dashboard. A local computer or cloud platform may be used according to the project budget.

VII. PROPOSED METHODOLOGY

7.1 Sensor data collection

Connect the soil-moisture and temperature-humidity sensors to the controller. Record readings at regular intervals and check for errors.

7.2 Image acquisition

Capture clear leaf images under suitable lighting. Label images by crop and condition where known.

7.3 Preprocessing

Clean sensor readings, handle missing values and resize/normalize images to the model's required input size.

7.4 Deep learning model

Train or fine-tune a CNN using labelled images of selected healthy and diseased leaf classes. Keep separate training, validation and test sets.

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7.5 Display and alerts

Display sensor readings and predicted image class. Configure crop-specific thresholds only after suitable values have been identified and validated.

VIII. WORKING PRINCIPLE

After the prototype is powered on, the controller reads the connected sensors. A camera captures a leaf image, which is sent to a computer or edge device for preprocessing and model inference. The trained model predicts an image class. Sensor readings are compared with configured reference limits. The interface displays readings and the image result together. If a reading crosses a selected limit or the model detects possible symptoms, the system can show a warning for further inspection. The output is decision support and not a substitute for expert diagnosis.

IX. EXPECTED OUTCOMES

The expected outcome is a prototype demonstrating sensor-based environmental monitoring and deep-learning-based leaf-image classification. It should present selected crop parameters and possible visual symptoms in one interface. Accuracy, response time and sensor error must be measured during implementation; no experimental performance result is claimed in this proposal.

X. ADVANTAGES AND APPLICATIONS

Supports frequent monitoring compared with occasional manual inspection.
Combines environmental readings with image-based observations.
Can be built using affordable and commonly available components.
May support irrigation planning, early warning and farm record keeping.
Can be adapted for small farms, greenhouses and educational demonstrations.

XI. LIMITATIONS AND FUTURE SCOPE

Sensor readings depend on placement, soil type, calibration and component quality. Image predictions may be less reliable when field images differ from training images because of lighting, background, crop variety or disease stage. Internet and power availability may also affect remote monitoring. Future work can include more crop varieties, field-collected datasets, sensor calibration, edge-device inference, multilingual alerts and long-term field trials. The model should be evaluated using accuracy, precision, recall, F1-score and a confusion matrix.

XII. CONCLUSION

This paper proposes an integrated crop-health monitoring approach using IoT sensors and deep learning. Sensor readings provide information about growing conditions, while image analysis can help identify visible leaf symptoms. Combining these inputs in a monitoring interface may help users observe crop conditions and investigate possible problems earlier. The next step is to build the prototype, collect representative data and evaluate it under real field conditions.

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Submission note: This is an introductory research-paper draft based on the supplied project title and author details. Verify the references and institute formatting before submission. Add actual implementation details and measured results only after completing experiments.