

IoT Based Smart Agriculture With Machine Learning

Nandini Pappa¹, Prema², Shivani³, Sneha M⁴, Snehalatha⁵, Manjula⁶

¹Professor, Department Of Electrical And Electronics Engineering, Appa Institute Of Engineering And Technology, Sharnbasva University, Kalaburagi, India.

^{2,3,4,5,6}Student, Department Of Electrical And Electronics Engineering, Appa Institute Of Engineering And Technology, Sharnbasva University, Kalaburagi, India.

ABSTRACT

This project presents an IoT and machine learning-based smart agriculture system designed to improve crop prediction, monitoring, and disease detection. The system uses sensors such as DHT11, soil moisture, and TDS sensors to collect real-time environmental data including temperature, humidity, soil moisture, and water quality. The collected information is transmitted through an ESP8266 Wi-Fi module to a cloud platform for storage and analysis. Machine learning algorithms process this data to predict the most suitable crop for cultivation based on current field conditions. In addition, the system supports image-based crop disease detection by analyzing leaf images through image processing and trained machine learning models. This helps identify plant diseases at an early stage and provides timely recommendations for preventive or corrective action. By combining IoT, cloud communication, machine learning, and image processing, the proposed solution enables farmers to make informed decisions, reduce crop losses, and improve productivity. The system also supports efficient resource use and promotes sustainable farming practices. Overall, this smart agriculture framework offers a cost-effective and reliable approach for precision farming, crop recommendation, and disease management in modern agriculture.

Keywords: Smart Agriculture, IoT, Machine Learning

INTRODUCTION

Agriculture is one of the most important sectors for food production and economic development. However, selecting the right crop based on environmental conditions such as soil moisture, temperature, humidity, and water quality is a challenging task for farmers. With the advancement of modern technologies, the integration of Internet of Things (IoT) and Machine Learning (ML) provides an effective solution for smart agriculture. IoT sensors like soil moisture sensor, DHT11, and TDS sensor are used to collect real-time environmental data from the field. This data is transmitted through a WiFi module to a cloud-based system. Machine Learning algorithms analyze the collected data and help in understanding suitable crop conditions based on environmental parameters. This enables better decision-making and improves agricultural productivity.

LITERATURE SURVEY

2.1 PROBLEM IDENTIFICATION

An accurate crop prediction model can help farmers to decide on what to grow and when to grow. Agricultural unpredictability, due to changing temperature season soil parameters are the factors which reduces productivity. More production should be gained with a larger population and area, however this is impossible to achieve. Farmers used to rely on word of-mouth, but owing to climate reasons, they can no longer do so. The adequate quantity and quality of fertilizers provide the essential nutrients to the soil for the sustained production of crops. To recommend the required fertilizer that the soil need and to stop the excess use of fertilizer which are not required to save the cost, there is a need of system which can make the work of farmer easy for them.

2.2 LITERATURE REVIEW

[1] "Soil Classification and Crop Prediction Using Machine Learning Techniques"

Authors: R. Ghadge, J. Kulkarni, P. More, S. Nene, and P. R. L.

Unsupervised and supervised learning algorithms like Kohonen Self Organizing Map and Back Propagation Network. Dataset is trained by learning networks to classify it into organic, inorganic and real estate for predicting the type of soil. It compares the accuracy obtained by different network learning techniques and the most accurate result is delivered to the end user. System will check soil quality and predict the crop yield accordingly along with it provide fertilizer recommendation if needed depending upon the quality of soil.

[2] "Real-Time Soil Analysis and Crop Recommendation Using IoT and Modified Support Vector Regression"

Authors: S. Pudasaini, A. Pathak, S. Sukamani, and M. Paudel.

Determines real time sampling of soil properties using MODIFIED SUPPORT VECTOR REGRESSION, a popular machine learning algorithm and four modules. The Modules include Sensor interfaced to IoT device, Agri cloud, Analyzing the real time sensor data and Agri user interface (AUI). The first module is portable IoT device (NodeMCU) with soil moisture sensor and pH sensor, environmental sensors. Agri cloud module consists of storage. Analyzing the real time data module is processing of types of crops and small plants suggested using modified support vector machine algorithm.

[3] "Crop Prediction Using ARIMA Model and Machine Learning Algorithms (K-Means and KNN)"

Authors: S. Veenadhari, B. Misra, and C. D. Singh

Predicts temperature, moisture and pH value for crop prediction using the ARIMA model. The model takes the values from database as input and then predicts what will be the value of that particular parameter after 1 month. The predicted values are then sent to K means algorithm for classification based on pH value thus creating k clusters of crops having similar pH value. KNN algorithm is used to predict top N suitable crops which are displayed to user.

[4] "Real-Time Crop Recommendation System Using KNN and IoT Sensors"

Authors: P. S. Nishant, P. S. Venkat, B. L. Avinash, and B. Jabber.

Machine Learning Algorithm (KNN) calculates the parameter to suggest the crop which is best to grow in the particular field based on the values received at real time. A standardized dataset containing the minimum requirements for a particular crop is maintained and is used for the prediction of the crop. The sensors are added to the field for which the readings are needed to be calculated. The DHT11, MQ2, Soil Moisture Sensor, Light Intensity Sensor sends the readings in real time to the cloud server.

[5] "Crop Yield Prediction and Quality Analysis Using Supervised and Reinforcement Learning Techniques"

Authors: R. Nageswara Rao and B. Sridhar.

Evaluates the crop quality factor based on pre-established weather conditions and nature of soil using the trained set of data and implementing Supervised and Reinforcement models of machine learning. If any unfavorable conditions are perceived ahead of time, the alternative and precautions measures are adopted so as to ensure the wellbeing of the planted crops and agricultural land. Specific measures are also taken to predict the right period of sowing, reaping and harvesting for the overall enhancement of the production which can also be foreseen as a part of the modern agricultural revolution.

IMPLEMENTATION AND METHODOLOGY

The proposed system combines Internet of Things (IoT) technology and Machine Learning techniques to assist farmers in making informed agricultural decisions. Initially, IoT sensors such as soil moisture sensors, temperature and humidity sensors (DHT11/DHT22), and other environmental sensors are deployed in the field to collect real-time data. This data is transmitted through the ESP8266 Wi-Fi module and stored in a cloud database for further analysis. Along with live sensor data, historical weather and rainfall data are also collected to improve prediction accuracy.

The collected data is then preprocessed and analyzed using machine learning algorithms. Based on parameters such as soil type, temperature, humidity, rainfall, and nutrient content, the system predicts the most suitable crop for cultivation. For disease detection, images of crop leaves are captured and processed using image processing and machine learning techniques to identify diseases at an early stage. After prediction and disease analysis, the system provides crop recommendations, fertilizer suggestions, and disease control measures through a user-friendly web or mobile interface. Finally, the performance of different machine learning models is evaluated, and the model with the highest accuracy is selected to ensure reliable results for farmers.

3.1 COMPONENTS

ARDUINO UNO

TDS SENSOR

DHT 11 SENSOR

ESP8266 Wi-Fi Module

TRANSFORMER

Voltage Regulator (7805/7812)

3.1.2 SOFTWARE REQUIREMENTS

PYTHON

FLASK

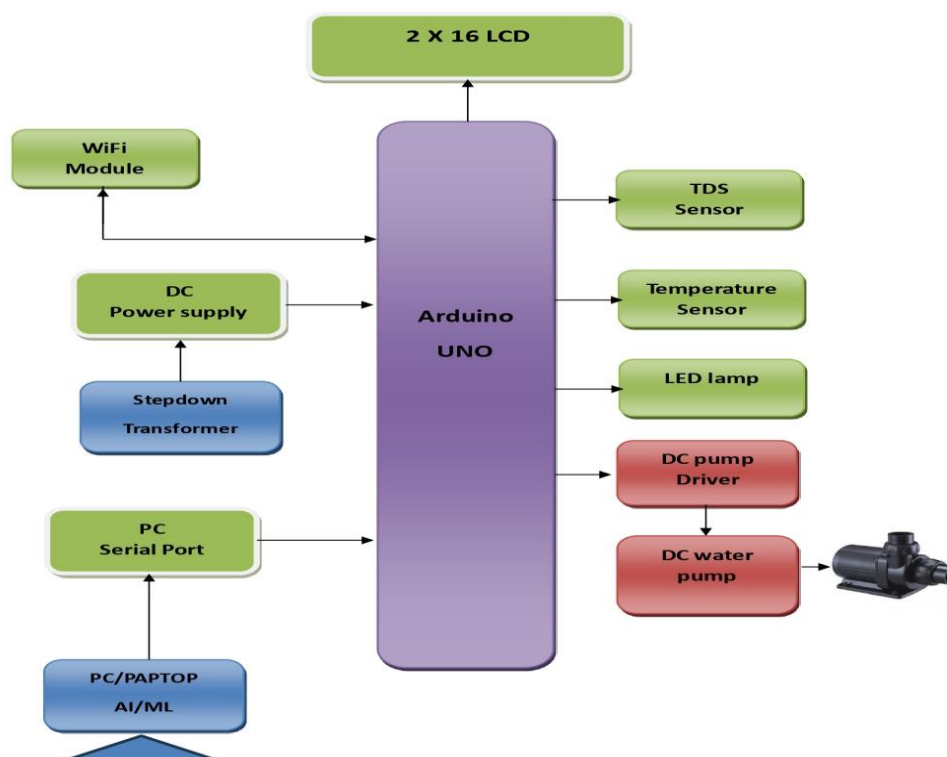
JINJA 2

NUMPY

3.2 WORKING

The proposed system integrates Internet of Things (IoT), Machine Learning (ML), and Image Processing technologies to assist farmers in crop selection and disease detection. The system consists of sensors, an Arduino Uno microcontroller, an ESP8266 Wi-Fi module, a cloud platform, and machine learning models.

Block Diagram



Initially, the DHT11 sensor measures environmental parameters such as temperature and humidity, while the soil moisture sensor monitors the water content in the soil. The TDS sensor measures the quality and nutrient content of water used for irrigation. These sensors continuously collect real-time field data and send it to the Arduino Uno, which processes the information and transmits it to the ESP8266 Wi-Fi module. The ESP8266 uploads the sensor data to a cloud platform where it can be monitored and stored for further analysis.

The collected environmental data is used as input to a machine learning model trained on agricultural datasets. Parameters such as temperature, humidity, soil moisture, rainfall, water quality, and soil conditions are analyzed to predict the most suitable crop for cultivation. The prediction results are displayed to the farmer through a web or mobile application, helping them choose crops that are best suited to the current environmental conditions.

For disease detection, the farmer uploads an image of a crop leaf through the application. The uploaded image undergoes preprocessing steps such as resizing, noise removal, and image enhancement. Image processing techniques are then applied to extract important features such as color variations, texture patterns, spots, lesions, and shape abnormalities present on the leaf surface.

The processed image is analyzed using a trained machine learning or deep learning model, such as a Convolutional Neural Network (CNN), which compares the extracted features with previously trained disease datasets. The model identifies whether the leaf is healthy or affected by a disease and classifies the type of disease. After successful detection, the system displays the disease name, symptoms, severity level, and recommended preventive or corrective measures to the farmer.

By combining sensor-based monitoring with image-based disease detection, the proposed system provides a comprehensive smart farming solution. Farmers can continuously monitor field conditions, receive crop

recommendations, detect diseases at an early stage, and take timely actions to improve crop yield, reduce losses, and promote sustainable agricultural practices.

3.3 IMPLEMENTATION

The proposed system is implemented using an Arduino Uno, DHT11 sensor, ESP8266 Wi-Fi module, 16×2 LCD display, regulated power supply, and control circuitry for automation. The regulated power supply converts 230V AC mains into a stable 5V DC supply required by the Arduino Uno, sensors, and communication modules. The DHT11 sensor is connected to the Arduino Uno to continuously monitor temperature and humidity conditions in the agricultural field.

The Arduino Uno acts as the central controller and processes the sensor data received from the DHT11 sensor. The measured environmental parameters are displayed on the 16×2 LCD display for local monitoring. Simultaneously, the Arduino communicates with the ESP8266 Wi-Fi module through serial communication, enabling the transmission of sensor data to a cloud platform for remote monitoring and analysis.

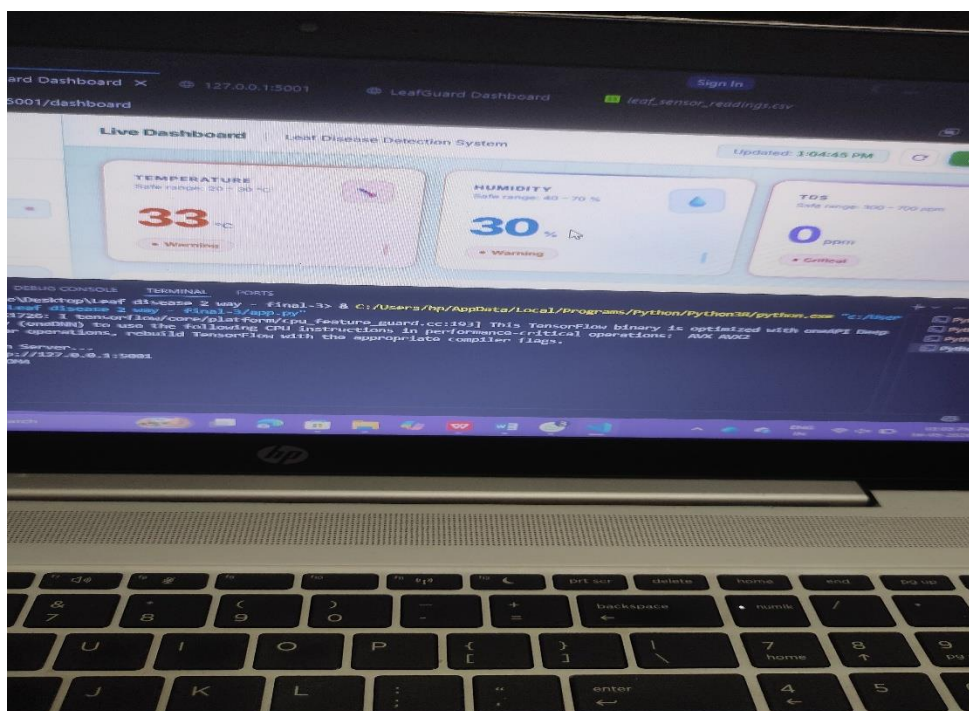
The system also incorporates control circuitry using optocouplers and relay-based switching to operate external devices such as a water pump and indicator lamp. Based on predefined threshold values or machine learning predictions, the Arduino can automatically activate or deactivate the pump to maintain suitable environmental conditions. The LED indicator provides the status of system operation.

For crop prediction, the sensor data collected through the IoT setup is uploaded to the cloud database and analyzed using machine learning algorithms. Parameters such as temperature, humidity, soil moisture, water quality, and rainfall data are used to predict the most suitable crop for cultivation. For disease detection, the user uploads an image of the crop leaf through a web application. The uploaded image is processed using image processing techniques and analyzed by a trained machine learning model to identify diseases and provide appropriate recommendations.

The integration of IoT hardware, cloud communication, machine learning algorithms, and image-based disease detection creates a smart agriculture system capable of real-time monitoring, crop recommendation, automated control, and early disease identification.

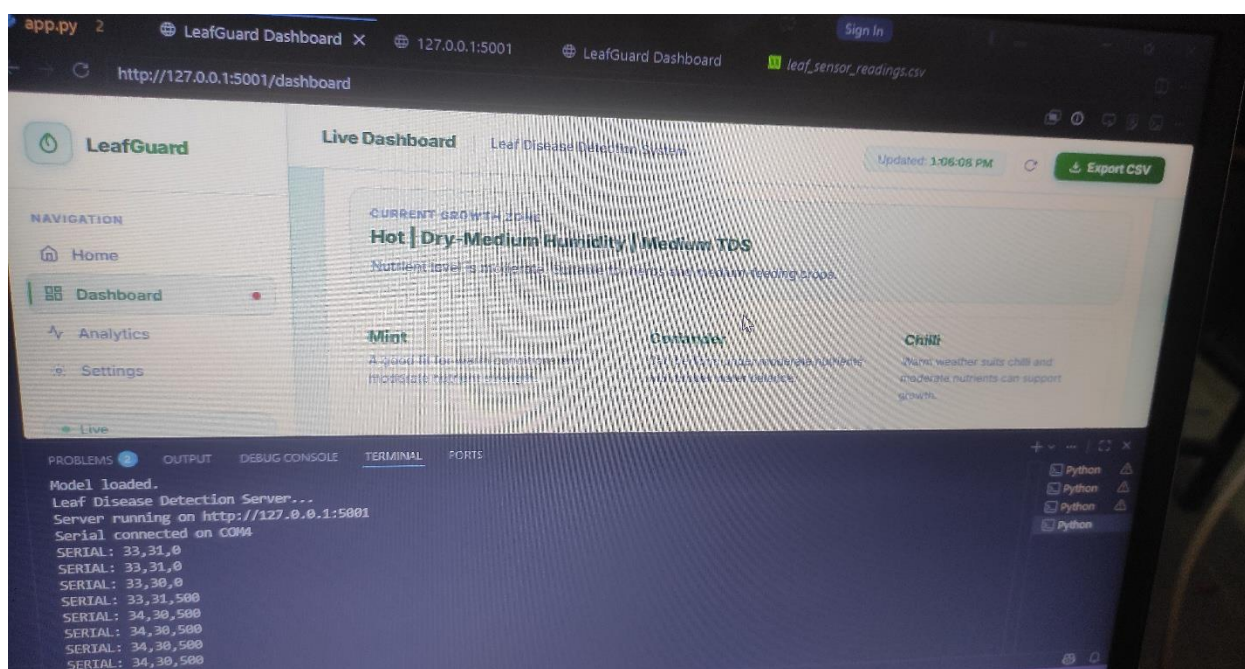
RESULT AND DISCUSSION

The proposed IoT and Machine Learning-based smart agriculture system was successfully implemented and tested. The DHT11 sensor accurately monitored environmental parameters such as temperature and humidity, and the collected data was displayed on the LCD screen as well as transmitted to the cloud through the ESP8266 Wi-Fi module. Real-time monitoring enabled continuous observation of field conditions and provided reliable input data for analysis.



The machine learning model was trained using agricultural datasets containing environmental and soil parameters. Based on the input data, the system successfully predicted suitable crops for cultivation under specific conditions. The prediction results demonstrated that machine learning techniques can assist farmers in selecting crops that are compatible with existing environmental conditions, thereby improving productivity and resource utilization.

For disease detection, crop leaf images were uploaded through the application and processed using image analysis techniques. The trained model successfully identified diseased and healthy leaves and classified different plant diseases with satisfactory accuracy. Early detection of diseases allows farmers to take preventive measures and reduce crop losses.



The integration of IoT-based monitoring with machine learning-based prediction and disease detection provided a comprehensive smart farming solution. The experimental results indicate that the proposed system can support

farmers in making informed decisions related to crop selection, irrigation management, and disease control. Overall, the system improves agricultural efficiency, reduces manual effort, and promotes sustainable farming practices through real-time monitoring and intelligent decision support.

ADVANTAGES, DISADVANTAGES AND APPLICATIONS

5.1 ADVANTAGES

1. Provides accurate crop prediction.
2. Improves agricultural productivity.
3. Reduces crop failure risk.
4. Saves time and manual effort.
5. Real-time monitoring using IoT.
6. Easy data access through internet.
7. Better decision making using Machine Learning.
8. Cost-effective for smart farming.

5.2 DISADVANTAGE

1. Initial setup cost is high.
2. Needs technical knowledge.
3. Sensor maintenance required .

5.3 APPLICATIONS

1. Smart farming :
This system helps farmers use modern technology to monitor field conditions and make better decisions, improving overall farm management.
2. Precision agriculture :
It allows accurate monitoring of soil and environmental parameters, helping in efficient use of water, fertilizers, and other resources.
3. Crop selection planning :
The system predicts suitable crop conditions, helping farmers choose the right crop for maximum yield and minimum loss.
4. Agricultural research :
Researchers can use this system to study environmental conditions and their impact on crop growth.
5. Soil and environmental monitoring :
The system continuously checks soil moisture, temperature, and humidity, helping in maintaining healthy soil conditions.
6. Sustainable agriculture :
It promotes efficient use of resources and reduces waste, supporting environmentally friendly farming practices.

CONCLUSION

This project presents an IoT and Machine Learning-based smart agriculture system for crop prediction and disease detection. The proposed system utilizes sensors to collect real-time environmental data, which is analyzed using machine learning algorithms to recommend suitable crops for cultivation. Additionally, image-based disease detection enables the identification of plant diseases at an early stage, allowing farmers to take timely corrective actions. The integration of IoT, machine learning, and image processing provides continuous monitoring, intelligent decision-making, and efficient resource management. The results demonstrate that the proposed system can improve crop productivity, reduce losses due to diseases, and support sustainable farming practices. Therefore, the developed solution offers a cost-effective and reliable approach for modern precision agriculture and can contribute significantly to enhancing agricultural efficiency and food security.

FUTURE SCOPE

The proposed IoT and Machine Learning-based crop prediction and disease detection system can be further enhanced by incorporating advanced technologies and additional agricultural parameters. In the future, more sensors can be integrated to monitor soil pH, nutrient levels, rainfall, and weather conditions for improved prediction accuracy. Advanced deep learning models can be employed to achieve higher accuracy in disease detection and classification.

The system can also be expanded to provide automated irrigation control based on real-time soil conditions, reducing water consumption and improving resource management. Integration with satellite imagery, drone-based monitoring, and weather forecasting services can further enhance decision-making capabilities. A web application with multilingual support can be developed to make the system more accessible to farmers in rural areas. Additionally, cloud-based data analytics and artificial intelligence techniques can be utilized to generate personalized recommendations, predict crop yield, and support large-scale smart farming applications.

REFERENCES

- [1] R. Ghadge, J. Kulkarni, P. More, S. Nene, and P. R. L., "Soil Classification and Crop Prediction Using Machine Learning Techniques," International Journal of Computer Applications / Conference on Smart Agriculture Systems.
- [2] "Real-Time Soil Analysis and Crop Recommendation Using IoT and Modified Support Vector Regression," Proceedings of International Conference on IoT in Agriculture / IEEE Conference,
- [3] "Crop Prediction Using ARIMA Model and Machine Learning Algorithms (K-Means and KNN)," International Journal of Data Science and Agricultural Informatics.
- [4] "Real-Time Crop Recommendation System Using KNN and IoT Sensors," International Journal of Engineering Research & Technology (IJERT) / IEEE Conference.
- [5] "Crop Yield Prediction and Quality Analysis Using Supervised and Reinforcement Learning Techniques," International Journal of Advanced Agricultural Research / Smart Farming Conference.