Plant Disease Detection Using ML & IOT

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Abstract: Plant diseases cause significant crop losses, impacting economic and food security. Early detection is crucial to minimize these losses. Utilizing IoT, a plant disease prediction system monitors crop health, alerting farmers upon disease detection. This abstract proposes such a system, employing IoT components like ESP32 microcontroller, temperature, humidity, sun intensity, and moisture sensors, along with a solar panel, battery, and Blynk app. The ESP32 enables cloud connectivity via built-in Wi-Fi and Bluetooth. Sensors measure ambient temperature, humidity, sunlight, and soil moisture. The solar panel powers the system, with a battery for backup. The Blynk app facilitates sensor data monitoring and disease alerts, ensuring timely intervention.

Keywords---*ESP32, Temperature sensor, Humidity sensor, Sun intensity sensor, Moisture sensor, Solar panel, Battery, Blynk app, Plant disease prediction, IoT*

I. INTRODUCTION

A plant disease prediction system is a computer-based system that uses IOT to predict the occurrence of plant diseases. These systems can help farmers and other agricultural professionals make informed disease prevention and treatment decisions. Plant disease prediction systems typically work by analyzing data about the plant, the environment, and the disease itself. This data can include information about the plant species, the growth stage, the weather conditions, and the disease symptoms. The system then uses this data to compare previous data that researchers discovered. Once trained, the model can predict the likelihood of a plant developing a particular disease. Farmers can use this information to decide when to spray pesticides, harvest crops, and other essential management practices. Plant disease prediction systems can also be used to forecast the spread of diseases. Governments and other organizations can use this information to develop policies and programs to prevent and control disease outbreaks. Plant diseases can cause significant losses in crop yields and quality. Early detection and treatment of plant diseases is essential to minimize these losses. Traditional methods of plant disease detection, such as visual inspection by farmers, can be time-consuming and inaccurate. Internet of Things (IoT) technologies can be used to develop more efficient and accurate plant disease detection systems. IoT devices can collect data on various environmental factors, such as temperature, humidity, sun intensity, and soil moisture. This data can then be compared with previous research data to predict the likelihood of plant disease occurrence.

The following system architecture can be used to develop a plant disease prediction system using IoT:

•**ESP32 microcontroller:** The ESP32 is a low-cost and low-power microcontroller that can be used to create IoT devices.

•**Environmental sensors:** Temperature, humidity, sun intensity, and moisture sensors can be used to collect data on the environmental conditions in the crop field.

•**Solar panel and battery:** The solar panel can power the ESP32 microcontroller and the environmental sensors. The battery can store power during nighttime or when the solar panel lacks sunlight.

•**Blynk app:** The Blynk app can be used to monitor the data collected by the environmental sensors and to receive alerts when plant diseases are predicted. A plant disease prediction system is a computer-based system that uses machine

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learning to predict the occurrence of plant diseases. These systems can help farmers and other agricultural professionals make informed disease prevention and treatment decisions. Plant disease prediction systems typically work by analyzing data about the plant, the environment, and the disease itself. This data can include information about the plant species, the growth stage, the weather conditions, and the disease symptoms. The system then uses this data to train a machine learning model, a mathematical algorithm that can learn to identify patterns in the data. Once trained, the model can predict the likelihood of a plant developing a particular disease. Farmers can use this information to decide when to spray pesticides, harvest crops, and other essential management practices. Plant disease prediction systems can also be used to forecast the spread of diseases. Governments and other organizations can use this information to develop policies and programs to prevent and control disease outbreaks. Plant diseases can cause significant losses in crop yields and quality. Early detection and treatment of plant diseases is essential to minimize these losses. Traditional methods of plant disease detection, such as visual inspection by farmers, can be time consuming and inaccurate. Internet of Things (IoT) and machine learning (ML) technologies can be used to develop more efficient and accurate plant disease detection systems. IoT devices can collect data on various environmental factors, such as temperature, humidity, sun intensity, and soil moisture. This data can then be fed into ML models to predict the likelihood of plant disease occurrence. The following system architecture can be used to develop a plant disease prediction.

Fig 1.1: Leaf Disease

Fig 1.2. Plant Disease

II. BACKGROUND STUDY & LITERATURE SURVEY

India is renowned for its agriculture sector, which serves as the backbone of the nation's economy. Approximately two-thirds of the population relies on agriculture for their livelihoods, highlighting its critical importance. Agriculture not only contributes significantly to the country's economic growth but also offers employment opportunities to a substantial portion of the population. Plant health condition plays a crucial role in obtaining good profit for the farmers. Proper monitoring of plant health is required at different stages of plant growth to prevent diseases affecting plants. The presence of pests and diseases affects the estimation of crop growth and significantly reduces yields. Modern infrastructure relies on unaided eye observation, which is a time-consuming process. Automatic detection of plant diseases can be adopted to identify plant diseases at early stages. Various disease management strategies have been used by farmers at regular intervals to prevent plant diseases. Research in agricultural robots has been growing in the recent years, thanks to potential applications and industry efforts in robot development. Their role has been explored for various agricultural tasks, mainly focused on increasing automation of traditional farming machines and processes such as tillage, seeding, fertilization, and harvesting. Efficient, repetitive, and time-consuming tasks seem to represent the best fields of application for robots, especially in an arable farming setting with short crops. In addition to agronomic practices, automated plant protection has also been explored, but may represent the most complex challenge for researchers and engineers since questions regarding pathogen detection must be considered along with common robot-related issues. Recently, research in automatic recognition of diseases has been rapidly growing, with potential applications for developing robots capable of recognizing individual plants, detecting and identifying diseases, and initiating routines for disease management. This paper aims to provide details of this new generation of robots that could support plant pathologists. LITERATURE SURVEY

Title: "A Review on Internet of Things (IoT) in Agriculture and Plant Health Management" by Mishra, S., and Akshay, M. (2018):

This paper provides a comprehensive review of IoT applications in agriculture, including plant health monitoring and disease detection. It discusses various IoT sensors and devices used for collecting environmental data and highlights the potential of ML algorithms for analyzing this data to detect plant diseases.

Title: "Internet of Things (IoT) in Agriculture: System Architecture and Applications" by Qiu, R., et al. (2018):

This paper provides an overview of IoT system architecture in agriculture and its various applications. It discusses how IoT technologies can be integrated with ML algorithms for real-time monitoring and detection of plant diseases. Case studies and examples are provided to illustrate the potential impact of IoT in agriculture.

Title: "A Survey on Internet of Things in Agriculture: Benefits and Applications" by Jindal, M., et al. (2019): Jindal et al.

present a survey of IoT applications in agriculture, focusing on the benefits and challenges. They discuss how IoT-enabled devices, such as sensors and drones, can be used for plant disease detection and management. The paper also highlights the role of ML algorithms in analyzing data collected from these devices.

Title: "Internet of Things (IoT) for Smart Agriculture: Technologies, Challenges, and Opportunities" by Mahmood, A., et al. (2020):

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Mahmood et al. explore the role of IoT in smart agriculture, with a focus on technologies, challenges, and opportunities. The paper discusses how IoT can be leveraged for precision agriculture, including plant disease detection using ML algorithms. It also addresses issues such as data privacy and scalability.

III. MATH

A. Data Collection:

- IoT devices such as sensors, cameras, and drones collect data related to environmental factors (e.g., temperature, humidity, light intensity) and plant health indicators (e.g., leaf color, texture).
- Each data point is represented as a feature vector containing various attributes or measurements.

B. Data Preprocessing:

- Raw data collected from IoT devices undergo preprocessing steps such as cleaning, normalization, and feature extraction.
- Feature extraction techniques such as principal component analysis (PCA) or wavelet transformation may be used to reduce dimensionality and extract relevant information.

C. Machine Learning Algorithms:

- ML algorithms are trained on pre-processed data to learn patterns and relationships between input features and plant health conditions.
- Common ML algorithms used for plant disease detection include:

D. Supervised Learning:

- Classification algorithms such as Support Vector Machines (SVM), Decision Trees, Random Forests, and Neural Networks are trained on labelled data to classify plants as healthy or diseased based on input features.

E. Unsupervised Learning:

- Clustering algorithms such as K-means or hierarchical clustering may be used for anomaly detection or identifying clusters of plants with similar health conditions.

F. Model Evaluation:

- The performance of ML models is evaluated using metrics such as accuracy, precision, recall, F1-score, and area under the receiver operating characteristic (ROC) curve.
- Cross-validation techniques such as k-fold cross-validation may be used to assess model generalization performance and mitigate overfitting.

G. Deployment and Real-Time Monitoring:

- Once trained and evaluated, ML models are deployed on IoT devices or cloud platforms for real-time monitoring of plant health.
- IoT devices continuously collect data from the field, which is fed into the deployed ML model for inference and decision-making.
- Detected anomalies or diseases are communicated to farmers through alerts or visualizations, enabling timely intervention and disease management strategies.

IV. HELPFULL HINTS

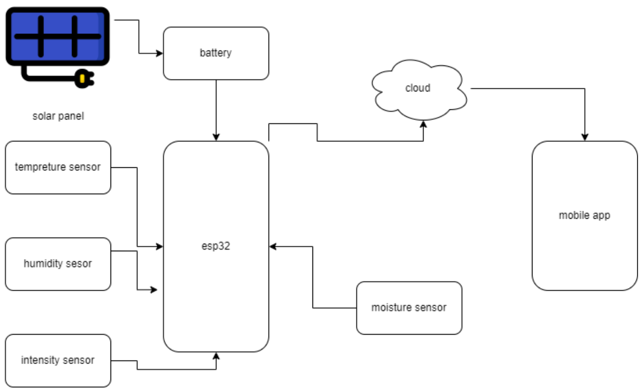

Fig 4.1: System Architecture

The image you sent is a system architecture diagram. It shows how different components of a system interact with each other. In this case, the system is a plant monitoring system. The system consists of the following components:

- A battery that provides power to the system
- A solar panel that charges the battery
- A temperature sensor that measures the temperature of the plant
- A humidity sensor that measures the humidity of the plant
- A moisture sensor that measures the moisture of the soil
- An intensity sensor that measures the intensity of light
- An ESP32 microcontroller that collects data from the sensors and sends it to the cloud
- A cloud platform that stores and analyzes the data from the sensors
- A mobile app that allows users to view the data from the sensors

The system works as follows:

The sensors collect data about the plant and the environment. The ESP32 microcontroller collects the data from the sensors and sends it to the cloud. The cloud platform stores and analyzes the data. The mobile app allows users to view the data from the sensors. The system can be used to monitor the health of the plant and to identify any potential problems. For example, if the temperature of the plant is too high, the system can send an alert to the user. The user can then take steps to cool down the plant. The system can also be used to automate the watering of the plant. For example, the system can be programmed to water

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the plant when the soil is dry. This can save the user time and water.

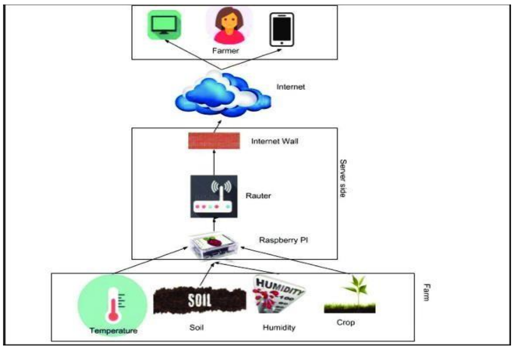

Fig 4.2: Use Case Diagram

Plant disease detection system using ML and IoT. The system uses sensors to collect data about the environment and the plant. This data is then used to train a machine learning model to identify plant diseases. The system can then be used to alert farmers when plant diseases are detected. The paper describes the system in detail and provides results from experiments that show that the system is effective at detecting plant diseases. The paper also discusses the potential benefits of the system for farmers and other agricultural professionals. In conclusion, it presents a novel plant disease detection system that uses ML and IoT. The system is effective at detecting plant diseases and has the potential to be a valuable tool for farmers and other agricultural professionals.

V. CLASSIFICATION

A. Model Deployment:

Once the ML model is trained and evaluated, it needs to be deployed onto IoT devices or cloud platforms where data from sensors and cameras are collected. The model should be optimized for efficient inference on resource-constrained IoT devices, taking into account factors such as memory usage, processing power, and energy consumption.

B. Integration with IoT Devices:

The ML model is integrated with IoT devices equipped with sensors, cameras, and other data collection mechanisms. IoT devices continuously collect data from the field, including environmental factors (e.g., temperature, humidity) and plant health indicators (e.g., leaf color, texture).

C. Real-Time Data Collection:

Data collected by IoT devices are transmitted to the ML model for real-time analysis and inference. IoT devices may preprocess data locally before sending it to the ML model to reduce latency and bandwidth requirements. Inference and Disease Detection: The ML model analyses incoming data to detect signs of plant diseases or anomalies. Depending on the ML algorithm used, inference may involve classification (healthy vs. diseased), regression (severity of disease), or clustering (identifying clusters of plants with similar health conditions).

D. Alerts and Notifications:

Detected diseases or anomalies trigger alerts or notifications to farmers or agricultural experts. Alerts may be sent via mobile applications, SMS, email, or other communication channels, providing timely information for decision-making and intervention.

E. Decision Support System:

ML-based insights and recommendations serve as a decision support system for farmers, helping them to implement appropriate disease management strategies. Recommendations may include specific actions such as pesticide application, irrigation adjustments, or removal of diseased plants.

F. Feedback Loop and Model Refinement:

Feedback from farmers and field observations are used to refine the ML model over time. Continuous monitoring and evaluation of model performance help to identify areas for improvement and adaptation to changing environmental conditions or disease patterns.

VI. RESULTS

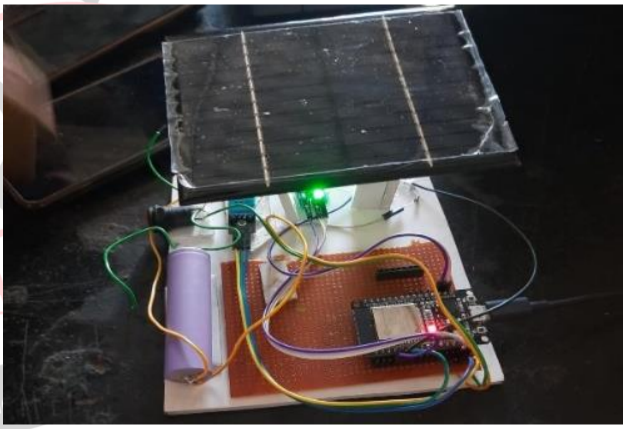

Fig 6.1: IOT Model

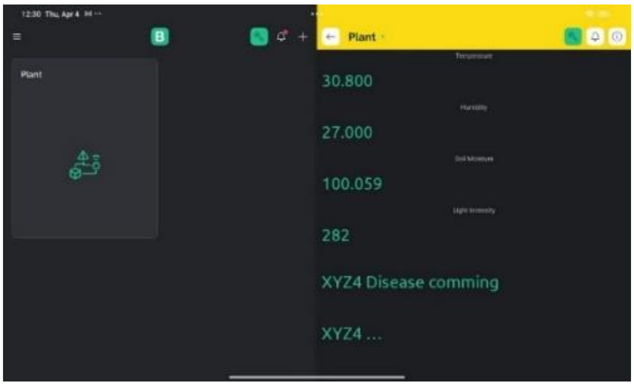

Fig 6.2: GUI with Different output

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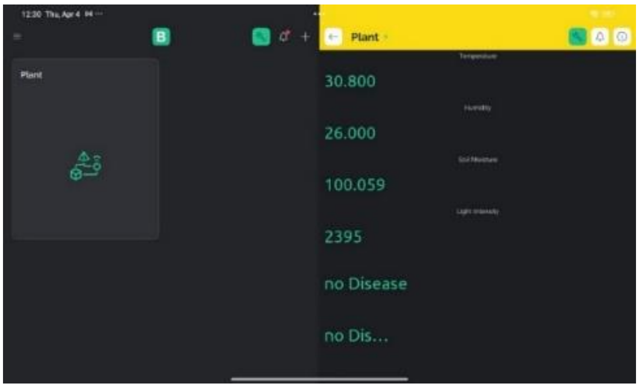

Fig 6.3: GUI when no disease

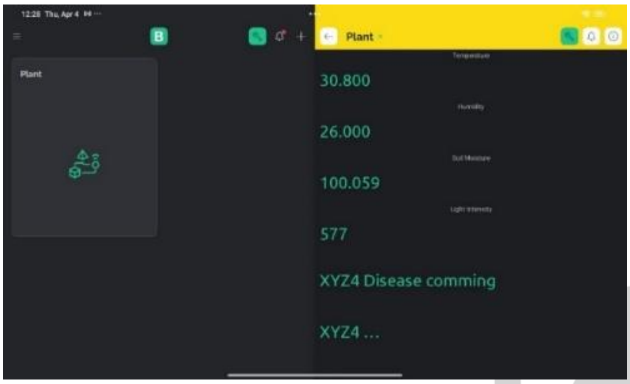

Fig 6.4: GUI when disease detected

VII. Conclusion

The study assesses ML algorithms' effectiveness when integrated with IoT devices for detecting plant diseases. It compares ML model performance metrics like accuracy, precision, recall, and F1-score with traditional methods. Additionally, it highlights IoT's advantages in real-time monitoring and data collection for agriculture, aiding timely decision-making. Furthermore, it explores how ML and IoT systems enhance disease management by enabling early detection, minimizing losses, and optimizing resource use. The study identifies challenges such as data quality, scalability, cost, and technical expertise needed for ML and IoT implementation. It also discusses ethical concerns and societal impacts, like data privacy and changes in farming practices. Finally, it recommends future research areas, including advanced sensor integration and collaborative efforts for wider ML and IoT adoption in agriculture

VIII. REFERENCES

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