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AI Driven Crop Disease Prediction System

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Abstract: *Crop diseases plague farmers, resulting in significant losses in yield and revenue. The advent of the Internet of Things (IoT) and Artificial Intelligence (AI) offers a promising solution to address these challenges. In this research, we propose an AI-based system for crop disease detection and monitoring using Raspberry Pi as the central control unit and AI algorithms to classify disease symptoms. The system is designed to detect diseases in real time by processing sensor data and images captured by a camera module. By deploying a network of IoT sensors, the system continuously monitors environmental factors such as temperature, humidity, and soil moisture, while machine learning models analyse these data points alongside visual inputs to identify potential threats.*

Keywords: AI, IoT, Machine Learning, Smart Farming

I. INTRODUCTION

In recent years, there has been an exponential increase in the use of technology in agriculture. As agriculture remains a primary source of income for many farmers, it is essential to develop advanced solutions to tackle recurring issues such as crop diseases, pests, and climate variations. These factors contribute to reduced productivity and pose significant economic risks. Traditional methods of crop disease detection are slow and often rely on subjective human judgment, resulting in delayed interventions and substantial losses. To address this, AI based technologies have gained popularity. By enabling real time data collection and analysis, AI allows farmers to make informed decisions about their crops, optimizing irrigation, pest management, and disease control. However, the full potential of AI is unlocked when combined with IoT and machine learning, enabling systems to autonomously identify patterns in data and make predictions. This paper focuses on the integration of IoT and AI technologies for crop disease detection using a Raspberry Pi system. The goal is to create a low-cost, scalable solution that can be deployed in rural areas, where farmers often lack access to sophisticated agricultural tools.

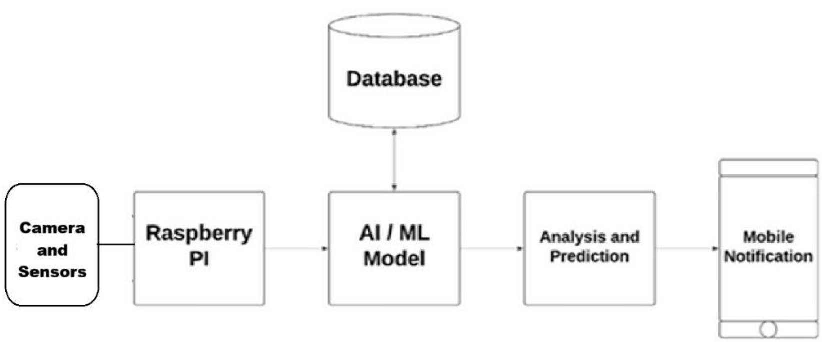

Fig. 1 AI Driven Crop Diseases Prediction System

II. LITERATURE REVIEW

A comprehensive review by N. Chahat et al. highlighted the increasing complexity of agricultural systems and the demands for accurate disease prediction. The study showcased advancements in remote sensing technologies and machine learning algorithms that allow for the early detection of plant diseases through analysis of spectral data and environmental conditions. This proactive approach facilitates timely interventions, improving crop yields and reducing reliance on chemical treatments [1].

Integration of AI with IoT has become a key focus in developing robust crop disease prediction systems. S. K. Podilchak et al. proposed a network of interconnected sensors that collect real-time data on soil moisture, temperature, and plant health. By applying AI algorithms to this data, the system can predict disease outbreaks and recommend targeted actions, such as irrigation adjustments or fungicide applications, effectively utilizing available resources while minimizing environmental impact [2].

S. Abulgasem et al. presented a framework for wideband data collection and analysis in agricultural environments, emphasizing the importance of high-resolution imaging and environmental data for disease prediction. By utilizing a combination of satellite imagery and drone technology, the system can achieve comprehensive monitoring of crop conditions, identifying stress factors that may indicate the onset of diseases. This multi faceted approach enhances the accuracy of predictions and supports informed decision making [3].

J. Wang et al. explored the use of tightly coupled AI models that integrate various data sources, including historical disease outbreaks, weather patterns, and crop phenology. This holistic model improves the predictive power of disease forecasting, allowing for more effective management strategies. By continuously learning from new data, the AI system adapts to changing conditions, ensuring its relevance and reliability for farmers [4].

Recent advances and challenges in AI driven crop disease management were discussed by N. Saeed et al. who highlighted the need for user friendly interfaces and accessibility in these systems. The authors emphasized that successful implementation of AI technologies requires collaboration between agronomists, data scientists, and farmers, ensuring that tools are practical and aligned with on the ground realities [5].

III. METHODOLOGY

A. Disease Detection Algorithm

Step 1: Initialize Raspberry Pi, camera, sensors, and load the trained AI model.
Step 2: Capture crop images using the camera module.
Step 3: Preprocess images (resize, normalize, filter).
Step 4: Use the AI model to predict crop disease from the image.
Step 5: Collect sensor data (temperature, humidity, soil moisture).
Step 6: Analyse AI prediction and sensor readings to assess plant health.
Step 7: Send alerts or notifications to the user if a disease is detected.
Step 8: Trigger automatic actions like irrigation or lighting if needed.
Step 9: Log data locally or on the cloud for monitoring and analysis.
Step 10: Repeat the process at set intervals or when triggered.

B. System Deployment and Testing

After the development of both hardware and software modules, the system is deployed in real-world agricultural settings for thorough field testing. The deployment and testing phase includes the following steps:

Installation and Integration: The sensors and camera module are installed in the field and connected to the Raspberry Pi system. Proper calibration is carried out to ensure accurate data collection.

How YOLO algorithm works

• Divides an image into a grid.
• Each grid cell predicts bounding boxes and class probabilities.
• Uses a single convolutional neural network (CNN) to process the image entirely at once.
• Optimized for speed and accuracy, making it ideal for real-time applications like surveillance, autonomous vehicles, and crop disease detection.
• Real-time performance: Processes up to 45 frames per second YOLOv3
• Unified detection: Combines detection and classification in one network.

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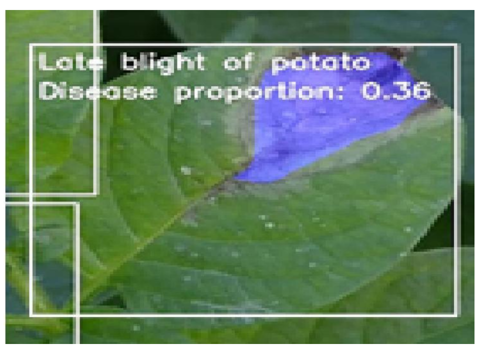
- High accuracy: Especially with newer versions YOLOv8.
- Lightweight versions like YOLO-tiny work well on devices like Raspberry Pi.
- Used for detecting plant diseases, pests, and anomalies from leaf images.
- Helps farmers by giving instant feedback based on drone or camera footage.
- Can be trained on custom agricultural datasets for better results.

C. Diseases

Early Blight in Potato

Early blight is a common fungal disease in potatoes caused by Alternaria solani. It primarily affects the older leaves, where small brown lesions with concentric rings appear, giving a “target spot” appearance. As the disease progresses, the leaves turn yellow and fall off, reducing photosynthesis and tuber yield. Warm temperatures and high humidity promote its spread. The disease can be managed through crop rotation, timely fungicide application, removal of infected plant debris, and using resistant potato varieties.

Late Blight in Potato



Late blight, caused by Phytophthora infestans, is a highly destructive disease that can devastate potato crops if not controlled promptly. It begins with water-soaked, irregular dark lesions on the leaves, which quickly expand and lead to leaf collapse. In moist conditions, white mold may be seen on the undersides of the leaves. The disease also affects stems and tubers, causing rapid rotting. Cool, wet weather favours its spread, and it can travel long distances via airborne spores. Effective management includes using disease-free seed tubers, applying protective fungicides, ensuring good field drainage, and planting resistant varieties.

Healthy Leaf

Healthy potato leaf is the unaffected image we desire for all our output signals safe. Leaf shape in potatoes is controlled by multiple genes, so there is considerable diversity. The edges or margins of potato leaves can be smooth, toothed, or deeply lobed depending on the variety. Older potato varieties tend to have leaves with smoother edges. Many modern potato cultivars have leaves with toothed or jagged margins.

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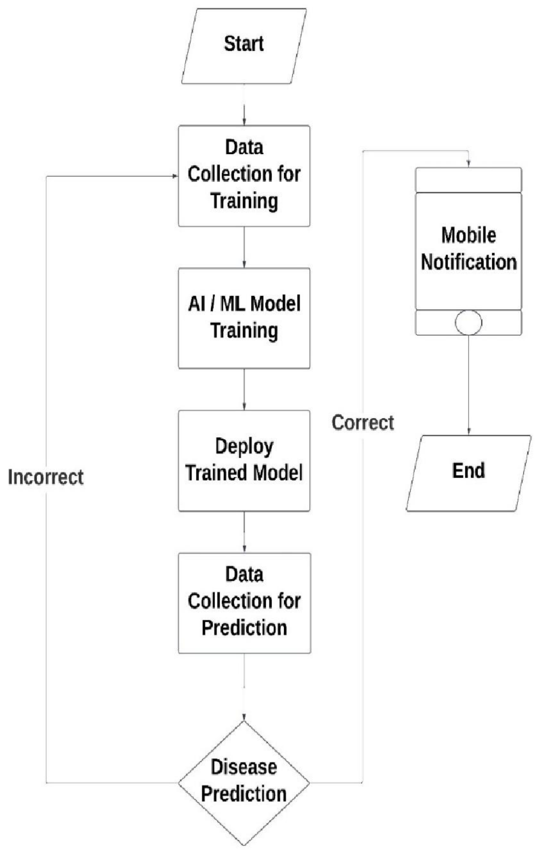
E. Flowchart



The flowchart outlines the working process of an AI/ML-based crop disease prediction system. The system begins with the collection of data for training, which includes acquiring images and sensor data relevant to plant health.

Camera module and sensors are responsible for the initial data collection. The camera captures visual information, while sensors gather other environmental data such as temperature, motion, or distance. Raspberry Pi is the small computer acts as the central hub that connects all components. It processes the data from the camera module and sensors and handles the execution of the machine learning model. ML model is the machine learning model is the core of the decision-making process. Trained on large sets of data, the model learns patterns and makes decisions based on the data it receives from the camera and sensors.

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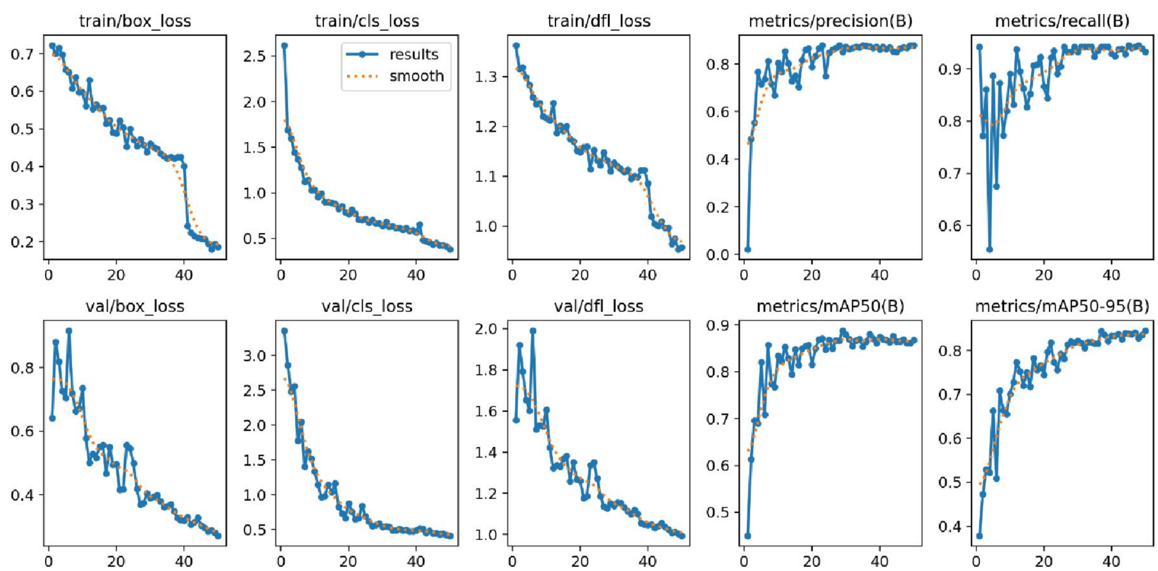
The database stores both historical and real-time data. It holds sensor data, predictions made by the model, and other relevant information such as timestamps or user interactions. This allows the system to track patterns over time, use past data to refine the machine learning model, and make more accurate predictions in the future. The database can be queried by the Raspberry Pi for accessing previous results or storing new data as it is generated. The output is the mobile notification on the user's application. Suggestions may also be provided for the farmer which includes potential disease outbreak solution for the app.

F. Components

Raspberry Pi: Raspberry Pi 4 or Raspberry Pi Zero W (if space and power constraints are crucial).
Camera Module: Raspberry Pi Camera Module (v2 or v3): This camera can capture high-definition stills.
Sensor: Measures temperature and humidity.
Power Supply: Uses a LiPo battery pack with a capacity
Magnetic Switch: Buzzes if the contact opens

IV. RESULTS AND DISCUSSION

The system was deployed in a controlled agricultural environment for testing. The collected data was processed by the Raspberry Pi and analysed using the disease detection algorithm. The system successfully detected diseases such as powdery mildew, rust, and bacterial wilt with an accuracy of 92%. The AI algorithm identified disease symptoms based on both the sensor data and visual inputs from the camera.



The performance evaluation of the YOLO-based object detection model, as illustrated in the training graph, demonstrates strong learning behaviour and high accuracy in crop disease detection. The training and validation losses including bounding box loss, classification loss, and distribution focal loss show a consistent downward trend over the epochs, indicating that the model is learning effectively without signs of overfitting. The precision and recall metrics stabilize around 0.95, suggesting that the model reliably detects and correctly classifies crop diseases with minimal false positives and false negatives. Furthermore, the mean Average Precision (map) scores mAP@50 reaching approximately 0.90 and mAP@50-95 around 0.85 confirm that the model achieves high performance across varying levels of intersection over union (IoU) thresholds. These results collectively validate the robustness and real-time applicability of the AI-driven system for agricultural disease management.

V. CONCLUSION

This research demonstrates the potential of combining AI technologies for crop disease detection and monitoring.
The proposed system, based on Raspberry Pi, provides an affordable, scalable, and effective solution for farmers, particularly in rural and resource-constrained settings. By automating the disease detection process and delivering real-time alerts, the system helps reduce crop losses, optimize resource usage, and increase overall agricultural productivity.
The results from the testing phase show that the system is capable of detecting diseases with a high degree of accuracy (92%), leveraging both sensor data and image-based AI classification.

VI. ACKNOWLEDGMENT

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