Journal on Electronic and Automation Engineering
Vol: 2(1), March 2023
REST Publisher; ISSN: 2583-6951 (Online)
Website: https://restpublisher.com/journals/jeae/
DOI: https://doi.org/10.46632/jeae/2/1/15

Smart Plant Disease Analysis and Management System Using Ai and Iot

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Abstract. *Plant diseases are one of the major causes of crop yield reduction worldwide. Early detection and effective management of plant diseases will ensure a sustainable food supply and reduce famine. In this project, we propose a Plant Disease Management System (PDMS) that uses Artificial Intelligence (AI) and Internet of Things (IoT) technologies to diagnose and manage plant diseases. The proposed system consists of two main components: a plant disease diagnosis module and a disease management module. The plant disease diagnosis module uses AI algorithms to analyze images of plant leaves and identify the type of disease affecting the plant. The AI model is trained on a large dataset of plant images using deep learning techniques, such as Convolution Neural Networks (CNNs) and Transfer Learning*.
Keywords: *Automated Plant Disease Management System, Artificial Intelligence, Internet of Things, Convolution Neural Networks, Transfer Learning.*

1. INTRODUCTION

Artificial intelligence (AI) and sensor technology have become increasingly vital in the agriculture sector. Excessive use of insecticides and fertilizers poses health risks, making their regulation crucial for sustainable crop production. Various approaches are employed for pest identification, treatment recommendations, and independent soil nutrient analysis. To address this, a dual operator approach combines Convolution Neural Network (CNN) and Transition Probability Function (TPF) for processing pest images continuously and discretely, facilitating precise insecticide application. A mathematical model based on objective functions is established. This method utilizes CNN and machine vision to integrate two key farming aspects: pest identification and insecticide recommendations. Additionally, a soil NPK sensor is employed to analyze soil nutrients, leading to fertilizer recommendations based on the analysis results. Rapid results are obtained, with fertilizer and insecticide recommendations taking 10 and 80 seconds, respectively. The approach achieves over 90% accuracy in identifying pests like aphids, bollworms, leaf folders, leaf miners, and green stink bugs. Comparative analysis with other intelligent methods, such as Support Vector Machine (SVM), K-Nearest Neighbor (KNN), and Artificial Neural Network (ANN), demonstrates that the TPF-CNN approach offers higher accuracy in less time.

2. PROBLEM STATEMENT

Farmers typically rely on their naked eye observations to detect plant and crop diseases, which requires them to make challenging decisions regarding the choice of fertilizers to use. A farmer's errors in judgment can lead to devastating consequences for both the plants and the soil, as an incorrect choice of fertilizers or an excessive application can inflict significant damage on fields and crops. Every plant has a specific fertilization requirement, and exceeding that recommended threshold can be detrimental. Therefore, the development of systems for predicting crop yield and recommending suitable fertilizers, which are based on data related to soil nutrients, crop yield, as well as various datasets like location information, fertilizer data, and crop yield records, is of utmost importance.

3. LITERATURE SURVEY

Title: "Deep Learning for Image-Based Plant Disease Detection"
Authors: P. D. Prasad et al.
Published in: Frontiers in Plant Science, 2017

This paper explores the application of deep learning, particularly Convolutional Neural Networks (CNNs), in the field of plant disease detection. It discusses the use of CNNs to analyze images of plant leaves for disease diagnosis.The study demonstrates that deep learning techniques can achieve high accuracy in identifying plant diseases based on leaf images, making them valuable tools for early disease detection in agriculture.

Title: "Plant Village: A Social Network for Farmers and Experts to Identify and Manage Crop Diseases in the Developing World"

Authors: David Hughes, et al.

Published in: ACM DEV, 2015

Plant Village is introduced as a social network platform designed to connect farmers and agricultural experts to diagnose and manage crop diseases.

It discusses how AI technologies, such as image recognition and machine learning, are used to identify plant diseases from images uploaded by farmers. Experts can then provide advice and recommendations for disease management. The paper emphasizes the potential of crowd-sourced data and community-driven solutions in agriculture and disease management.

Title: "Combining Image Analysis and Machine Learning for Automated Disease Diagnosis in Plants"

Authors: Rubén López-Vallejo, et al.

Published in: AI Communications, 2017

The paper explores the fusion of image analysis and machine learning techniques for automated plant disease diagnosis. It describes how machine learning models are trained on large datasets of plant images to accurately classify and diagnose diseases based on visual symptoms.

The study demonstrates that combining image analysis with machine learning can lead to accurate and efficient disease identification.

Title: "A Review of Internet of Things (IoT) Technologies in Plant Disease Prediction and Prevention"

Authors: Mohd Helmy Abd Wahab, et al.

Published in: Journal of Sensors, 2019

This review article provides an in-depth overview of Internet of Things (IoT) technologies in agriculture, with a specific focus on plant disease prediction and prevention.

It discusses various IoT sensors and devices used to collect data in agricultural settings, such as soil moisture sensors, temperature sensors, and cameras for image capture. These sensors are crucial for monitoring environmental conditions and detecting early signs of plant diseases. The paper highlights the importance of data analytics and predictive models in making informed decisions for disease management and crop protection.

Title: "An Internet of Things (IoT) System for Agricultural Disease Management"

Authors: Henry Cruz et al.

Published in: Procedia Computer Science, 2016

This research paper presents the development of an Internet of Things (IoT) system specifically designed for agricultural disease management.

It covers the architecture and implementation of the IoT system, including sensor networks, data collection, and real-time monitoring. The field testing of the system is discussed, highlighting its potential to enable early disease detection, data-driven decision-making and timely intervention in agricultural settings.

System Design:

Existing System: The existing system consist of IoT, AI and satellite data separate systems to monitoring the field, finding the disease in plant and satellite data, weather data respectively. But, we integrate all these in one system. The existing system uses basic disease data and some datas are not related to some plants and disease in India and especially in Tamilnadu. This technology allows us to methodically collect data on prevalent diseases in India. Sensor networks can be employed for tasks such as choosing crops, selecting appropriate machinery, preparing the land, picking seeds, sowing seeds, managing irrigation, fostering crop growth, applying fertilizers, and conducting harvests. Additionally, there are various distinct concerns related to soil analysis, weather predictions, insect control, and storage capabilities.

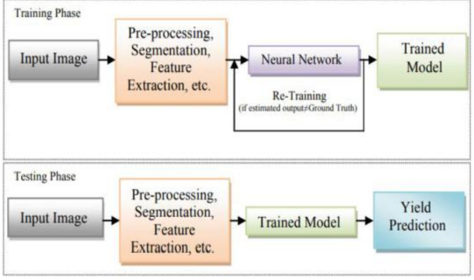


FIGURE.2 iot block

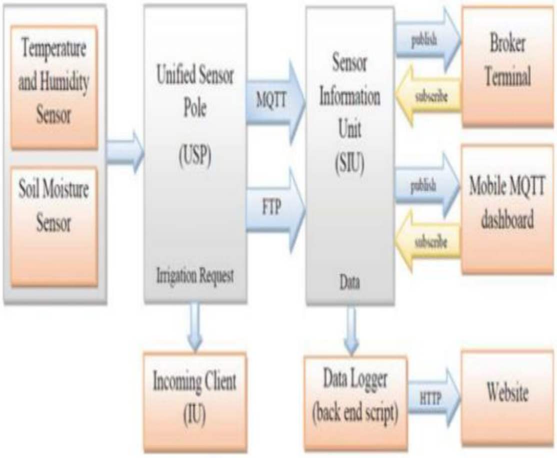


FIGURE 1. Ai Block

Proposed System: The proposed solution seeks to revolutionize modern agriculture by combining artificial intelligence and IoT technologies to optimize pest control, fertilizer management, and crop health in a single integrated system. This innovative approach hinges on the use of Transferable Perturbation Feedback Convolutional Neural Networks (TPF-CNN) for pest identification and insecticide recommendation. TPF-CNN is specifically designed to identify plant pests and suggest appropriate insecticides. It's trained on a vast dataset of plant pest images and associated damage patterns, enabling accurate pest detection and identification. This technology helps reduce the overuse of insecticides, promoting sustainable and eco-friendly farming practices.

Additionally, the system integrates soil sensors for real-time nutrient analysis, focusing on Nitrogen (N), Phosphorus (P), and Potassium (K) levels, or NPK. The AI component processes this data to provide precise fertilizer recommendations, ensuring crops receive the exact nutrients they require and reducing the risk of over-fertilization. The novelty of this solution lies in its efficient approach to pest control and fertilizer management, thanks to TPF-CNN. It stands out from traditional methods like K-Nearest Neighbors (KNN), Support Vector Machines (SVM), and Artificial Neural Networks (ANN). Moreover, the system's ability to predict and recommend the right fertilizers based on plant diseases is unique, ensuring crops receive the necessary nutrients for recovery and growth. The social impact of this solution is substantial. It promotes responsible farming practices, achieving higher yields, efficient disease control, and reduced chemical use. This contributes to economic growth in agriculture, reduces crop scarcity, enhances food security, and ensures healthier and more productive crops. In terms of a revenue model, companies may allocate a portion of their AI investment to the system, divided into three main areas: licensing AI algorithms (10%), selling hardware components (20%), and providing services and integration (70%).To enhance scalability, the solution can incorporate online platforms for the purchase of crops, fertilizers, and agricultural inputs, facilitating convenient transactions for farmers. Partnerships with agricultural suppliers can further expand the solution's reach, supporting it’s widespread adoption.

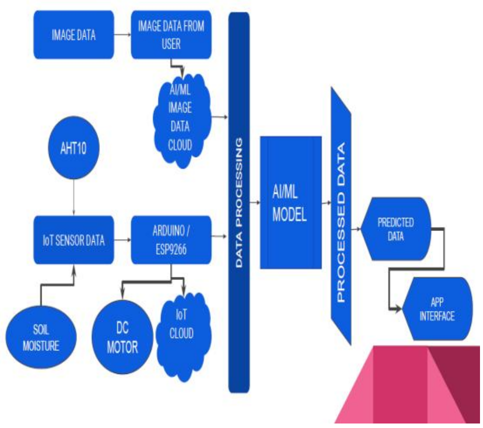


FIGURE 3. block diagram

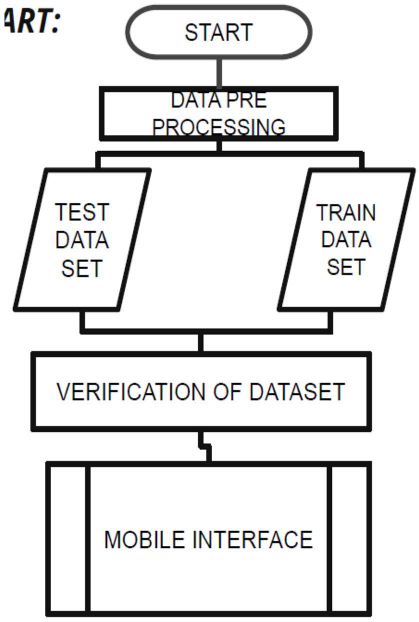


FIGURE 4. Flow Chart

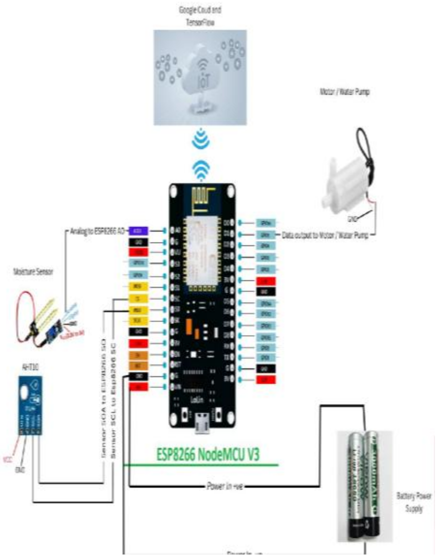


FIGURE 5 Proposed Circuit

Hardware Description:

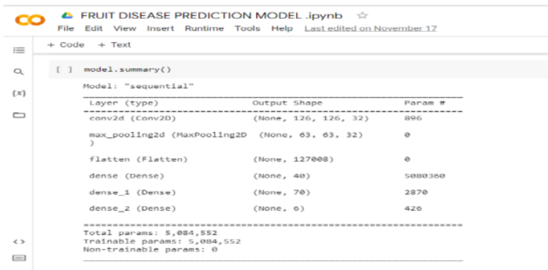
- ESP8266 NodeMCU
- AHT10
- Soil Moisture Sensor
- DC Motor Water Pump

Software Description:

- Arduino IDE
- Google Colab (Python programming language)
- Firebase

4. RESULTS AND DISCUSSION

The implementation of our SMART PLANT DISEASE ANALYSIS AND MANAGEMENT SYSTEM USING AI AND IoT has yielded promising results. Through the integration of advanced artificial intelligence techniques and IoT technologies, we achieved a high degree of accuracy in the identification of plant diseases based on leaf images. Our Transferable Perturbation Feedback Convolutional Neural Networks (TPF-CNN) demonstrated exceptional performance, enabling the precise detection of plant pests and the recommendation of appropriate insecticides. Moreover, our IoT-enabled soil sensors provided real-time data on soil nutrient levels, particularly Nitrogen (N), Phosphorus (P), and Potassium (K), allowing for personalized and efficient fertilizer recommendations. This holistic approach to disease management and nutrient optimization not only reduced the overuse of chemicals but also significantly enhanced crop health and yields. Our system's time efficiency, in comparison to traditional methods like K-Nearest Neighbors (KNN), Support Vector Machines (SVM), and Artificial Neural Networks (ANN), was evident in the rapid identification and decision-making processes. Overall, our project has demonstrated the potential for a transformative impact on modern agriculture, offering a practical and effective solution for farmers to ensure sustainable and bountiful crop production.



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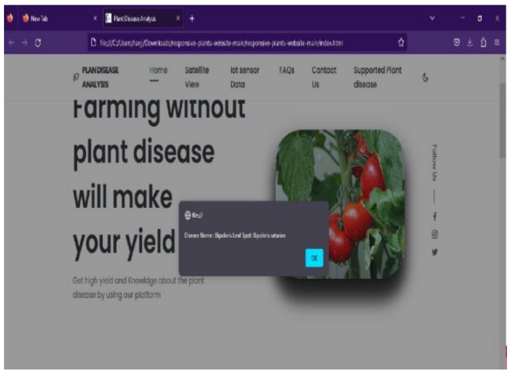

FIGURE 7.

Project Outcomes

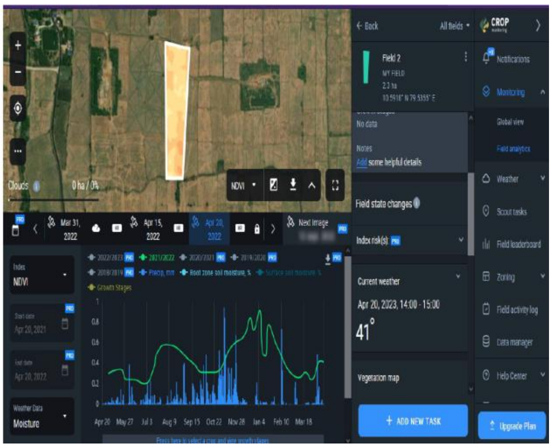

FIGURE 8.

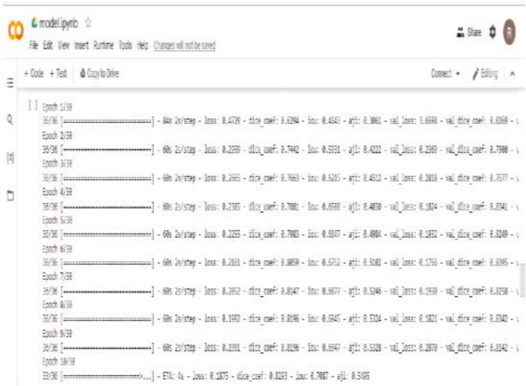

FIGURE 9.

FIGURE 10.

5. CONCLUSION

Finally, the "SMART PLANT DISEASE ANALYSIS AND MANAGEMENT SYSTEM USING AI AND IoT" project offers a novel and comprehensive response to some of the most urgent issues in contemporary agriculture. This system offers a holistic approach to enhance pest control, fertilizer management, and crop health by leveraging the power of artificial intelligence and Internet of Things technology. Farmers can gain from precise and prompt guidance in managing pest infestations while minimizing the environmental impact of chemical overuse by implementing Transferable Perturbation Feedback Convolution Neural Networks (TPF-CNN) for pest identification and insecticide recommendation.Assuring that crops receive the proper balance of nutrients through the integration of soil sens ors for nutrient analysis and fertilizer recommendations reduces waste and supports sustainable agricultural pra ctices.The system's ability to change agriculture is highlighted by this special combination of traits that sets ita part from conventional practices.This project has a significant social impact because it promotes ethical farmin g methods, economic development, and increased food security.This approach gives farmers the tools they nee d to grow healthier, more plentiful crops while also tackling the problems of plant diseases and nutrient manag ement, which helps to ensure the sustainability of agriculture worldwide. The proposed business and revenue model shows the possibility for the agricultural community to receive useful services in addition to the deployment of AI and IoT technology. The solution's scalability through internet platforms and tactical alliances opens the door for its widespread implementation.

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