International Journal Of Engineering Research And Development
e- ISSN: 2278-067X, p-ISSN: 2278-800X, www.ijerd.com
Volume 20, Issue 5 (May. 2024), PP. 161-165

Plant Monitoring System With Sensor Data And Image Processing

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Abstract: *Inorganic and manual practices have been prevalent in Indian farming culture for ages. This results in indirect toxin concentration in plants that are consumed by humans, leading to so many health issues . Adapting kitchen gardens in houses can, to some extent, help in the reduction of toxin consumption, but taking care of such gardens is a tedious task . The incorporation of IoT for plant monitoring can make small kitchen gardens' care more feasible for small families, and so they can adapt organic farming practices easily. Also, using image processing for disease detection in plants can also be proven helpful for the growers. The introduction of modern technologies such as IoT and image processing in our day to day practices can facilitate us for adapting new practices. In this project, we aim to employ soil moisture and DHT11 sensors for real-time monitoring of parameters such as soil moisture, temperature, and humidity, enabling efficient plant care. There is sufficient evidence showing that many plant diseases[1] occur due to variations in these parameters. The project's goal is not only to identify diseases but also to offer real-time monitoring of environmental conditions, allowing for the identification of disease causes and the implementation of necessary cautionary measures.*

Date of Submission: 11-05-2024 Date of Acceptance: 23-05-2024

I. INTRODUCTION

In India, the conventional practices of inorganic farming have been widespread among farmers. The increasing dependency on chemical inputs in intensive farming has disrupted the balance among soil, plant and human well being. Driven by the pursuit of higher yields, farmers have turned to chemical supplements inadvertently damaging the ecosystem [2]. The effect of inorganic farming on human health is alarming. This is because these chemicals are getting into the food chain and staying in nature for a long time. Exposure to these chemicals can result in acute effects such as skin irritation, respiratory issues and eye problems. Whereas long-term exposure may increase the risk of chronic diseases, including cancer, neurological disorders and reproductive connective complications[3].

Kitchen gardens offer a holistic and sustainable alternative to inorganic farming practices promoting health and community well-being. By growing their own fruits, vegetables and herbs, individuals can ensure that they are consuming fresh nutritious food which is free from harmful chemicals.Recently Kitchen gardens have gained popularity as a sustainable practice for growing fresh produce in residential spaces. However, traditional gardening methods often lack efficient monitoring mechanisms, making it challenging to detect early signs of plant diseases[4].Our project aims to create a fully automated and intelligent system for managing kitchen gardens using IOT and Image processing technologies.

II. LITERATURE REVIEW

In recent years, the interest in the field of plant monitoring systems with advancement in image processing has been growing significantly. Also, several studies have been done to highlight the potential of IoT based plant monitoring systems that helps improve productivity, reduce resource usage as well as manual labor. Let's walk through the overview of various such related researches. The use of inorganic fertilizers have been increasing continuously these recent years and although it helps in yield enhancement it poses serious threat to human and plants[5].To reduce the effect of inorganic fertilizers, a new agriculture practice called organic farming has been introduced which shows the prospects and potential of using organic fertilizers[6],[7] highlights how we can reduce resource wastage and adjust the water and fertilizer according to soil water content. For monitoring the aspects of the plants like its growth, temperature, humidity, diseases etc. various IoT based methods and technologies can be employed using which we can develop smart gardens with an automonitoring system[8].For disease detection in plants, data-aided tools and artificial intelligence-based methods are found effective. Deep learning methods like Convolutional Neural Networks (CNNs), Artificial Neural Networks (ANNs) etc. are precise, accurate and reliable as they learn and retain their data from surroundings and use it efficiently[9][10]. As we are actively focusing on working on smart technologies like AI and Machine Learning, some systems have been developed which support these technologies, like TensorFlow[11]. This system makes it easy to work on big farms and fields to identify crop and plant diseases.

III. Proposed Methodology

The aim is to develop an IOT based plant monitoring system which currently focuses on better and easy monitoring of plants for kitchen gardens by utilizing IOT technology and also applying Image processing and Machine learning model for disease detection.

3.1 Plant Monitoring System Requirements -

3.1.1 Node MCU : A low cost open source microcontroller whose firmware is based on Lua. It has an ESP8266 Wi-Fi SoC chip for Wi-fi functionality so that data transmission can be enabled over the internet using Wi-fi.The Arduino IDE software can be used to upload code in Node MCU.

3.1.2 DHT 11: The DHT 11 is a digital humidity and temperature sensor . This sensor measures temperature and humidity from the surroundings and produces digital readings as its output. It incorporates a thermistor (with negative temperature coefficient) for computing temperature and a capacitor for humidity quantification.

3.1.3 Soil Moisture Sensor: The Soil Moisture sensor is used for measuring the moisture content of soil. It uses a capacitance model for measuring dielectric permittivity of soil. The dielectric permittivity of soil being a function of moisture content of soil and so is used for moisture quantification of soil.

3.1.4 Blynk IoT: Blynk IoT is a low code software for connecting devices to the cloud over the internet . A graphical interface can also be developed using this platform that can fetch the data from the cloud and display it over various devices.

3.2 IoT Model implementation

A circuit has been designed consisting of Node MCU, a DHT 11 sensor and a Soil Moisture sensor. The sensors have been connected to digital pins of node mcu that takes sensor data and transmits it to the cloud through Wi-Fi. The sensor data readings can be fetched using the Blynk Iot platform (Web Dashboard and Mobile application) from anywhere. This arrangement ensures real time monitoring of plants .

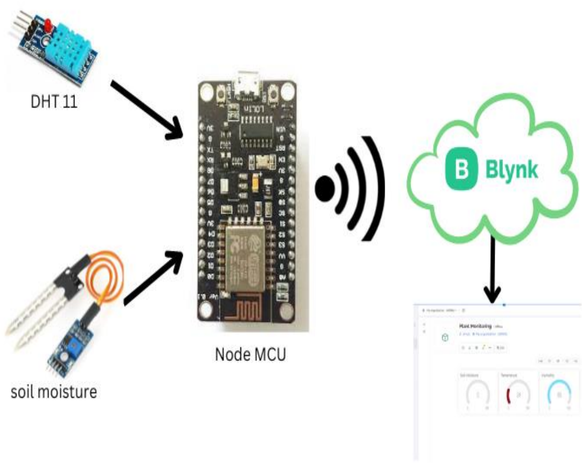

Fig.1 Plant Monitoring using IoT

3.3 Plant Disease Detection and Classification

Image recognition may be performed to identify diseased leaves. The paper [12] depicts the process of Image processing to detect and classify the affected plant. This section briefly discusses the various steps involved in image processing and the machine learning algorithms used.

3.3.1 Data Collection: This research used a public dataset collected by Kaggle titled "New Plant Diseases Dataset (Augmented) inspired by [13]. This dataset comprises approximately 87,000 RGB images of healthy and diseased crop leaves, categorized into 38 classes. The dataset is split into a training set and a validation set in an 80/20 ratio, maintaining the directory structure. Additionally, a new directory containing 33 test images is created for prediction purposes.

Fig.2 Data set visual representation.

3.3.2 Image Preprocessing: This step preprocesses the images of the dataset to enhance their quality for more effective analysis. The image_dataset_from_directory function, belonging to the Keras library [14], is used to preprocess the data, which includes resizing all images to (128, 128, 3) dimensions using bilinear interpolation.

3.3.3 Model Building: In this project, a Convolutional Neural Network(CNN) is used for model architecture. This model is constructed using the Sequential API from TensorFlow and Keras. In [15], the author mentions the features of the Convolutional Neural Network over conventional neural networks. The decision was based on the following factors:

- CNN model is similar to the human brain's ability to learn relevant features from images at different levels. Conventional neural networks are not able to do this.
- Weight sharing is a key characteristic of CNN that differentiates it from other neural network architectures. In CNN, each filter possesses a set of weights (parameters) that are applied across the entire input volume, enabling the network to extract features efficiently from the input. This concept is also referred to as parameter sharing.

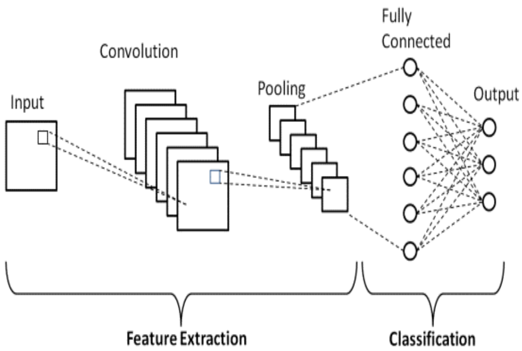

Fig.3 Convolution Layers

3.3.4 Performance Metrics: Performance metrics are used to evaluate the effectiveness or quality of a model. These metrics provide insights into how well our model performs on the given dataset. In this project, the Accuracy matrix and confusion matrix are used as performance metrics, inspired by [16].

- **Accuracy Metric:** The Accuracy metric is calculated as the ratio of correct predictions to the total number of predictions made by the model.

● **Confusion Matrix:** The confusion matrix is a tabular representation that describes the performance of a binary classifier on a test dataset, showing the number of correct and incorrect predictions.

3.3.5 Prediction and Classification: The model successfully predicted and classified the disease in the test image.

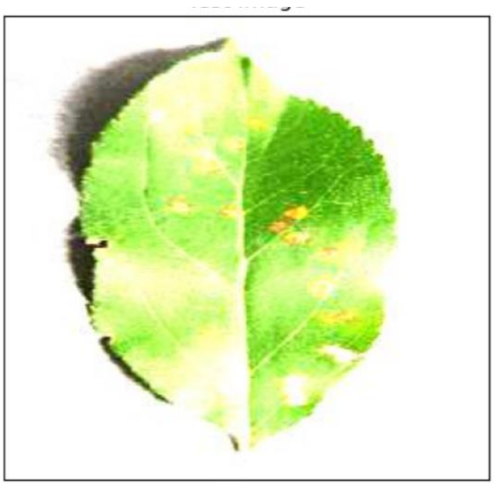

Fig.4 Test Image

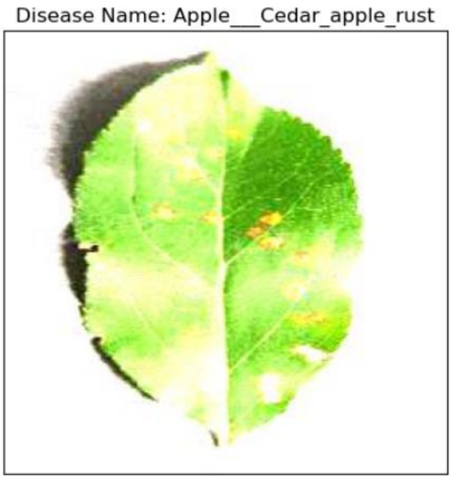

Fig.5 Output image with predicted disease

3.3.6 Function of IoT:

After proper diagnosis of disease by image processing,their root causes can be analyzed . There are so many diseases that are caused due to environmental conditions[17], so real time monitoring of these conditions by sensors and IoT can ensure appropriate actions for plant health.

IV. Result

The integration of environmental sensors with the Node MCU microcontroller enables this project to provide real-time data on soil moisture,temperature and humidity. Soil moisture levels are continuously monitored, allowing growers to fix irrigation schedules while the temperature sensor offers valuable insights into fluctuations in ambient temperature. Furthermore, the image processing program demonstrates high accuracy in disease detection, which helps in identifying issues such as nutrients deficiencies ,pest infestations and disease outbreak at an early stage. By analyzing images of plant leaves, subtle signs of diseases such as discoloration patterns or lesions, enabling early diagnosis. This helps growers intervene promptly to prevent crop damage[18] Hence, the combined functionality of plant monitoring and disease detection offers growers a complete set of tools for managing plant health effectively.Our project seeks to revolutionize kitchen gardening by harnessing the power of technology to create sustainable and efficient growing involvement.

V. Conclusion

To summarize the proposed work, we have discussed the development and implementation of a plant monitoring system based on IoT and machine learning with image processing for disease detection. The IoT based system can monitor humidity, temperature and soil moisture using sensors to accumulate the data required for monitoring plant's surroundings and the system also provides real-time monitoring to users. Real-time monitoring helps the user to collect and analyze the data so that they can make decisions regarding pest management, irrigation etc. The precise and accurate detection of plant disease is done by image processing with the help of AI and machine learning tools, like CNN and TensorFlow. Above discussed system can be used to detect issues such as nutrient deficiencies, pest infestations, and disease outbreaks early on, enabling prompt intervention and preventing crop damage. The proposed system can be used for small kitchen gardens to effectively monitor plant's health and growth, and to also detect diseases early on.

VI. Future Scope

The project holds great potential for enhancing and revolutionizing traditional agricultural practices. This project is designed for kitchen gardens but can be introduced for larger scale agriculture without much changes. Introducing more sensors such as light intensity , soil pH sensors etc can make the project more efficient.Integrating NPK sensors data with machine learning to develop a model for proper analysis of soil nutrients can cater to an efficient soil monitoring system that facilitates reduction even complete cessation of fertilizers usage for crops, and hence promoting organic farming[19].

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