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To Increase the Crop Production and to Predict the Leaf Disease

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Abstract: *Crop production plays a critical role in ensuring food security and meeting the growing demands of an expanding global population. However, challenges such as limited arable land, water scarcity, climate change, and pest pressures pose significant threats to agricultural productivity. Therefore, developing effective strategies to increase crop production is imperative for sustainable agricultural and food systems. Firstly, precision agriculture techniques offer great potential for improving crop productivity, these include sensing technologies to monitor the crop health, and optimize the fertilization practices. By precisely tailoring inputs to crop requirements, farmers can reduce resource wastage and maximize yields, and healthy soils with improved nutrient- cycling and reduced diseases contribute to higher yields and long-term agricultural sustainability.*

Moreover, efficient and optimal crop management is also needed in hand to improve the essential phase of productivity of the crop and the demand of the population. To achieve this, the integration of technology-driven solutions can greatly aid farmers in making informed decisions regarding crop selection and fertilizer suggestion. The crop recommendation module recommends the crop to the user by the parameters given by the user to the application. The fertilizer suggestion module suggests the needed fertilizer for the soil by the nutrient level trained in the set. And the leaf disease module predict the disease and it would tell the precaution measures to the user by detecting the diseases. In addition to the point agriculture is predominant area in the economy of all corners. However there need to be improvision version to increase the crop production and this is done using machine learning and deep learning methods. This journal offers a thorough description of the modules

Keywords: Machine Learning, Deep Learning, Convolutional Neural Network, Dataset

I. INTRODUCTION

Agricultural productivity is a crucial aspect of ensuring food security and addressing the challenges posed by a growing global population. To meet the increasing demand for food, it is essential to adopt strategies that enhance crop production while effectively managing threats such as leaf diseases. Leaf diseases, caused by pathogens ad environmental factors, significantly impacting the crop health and crop yield. Therefore, integrating approaches to increase crop production and predict leaf diseases plays a vital role in sustainable agriculture.

The first objective is to enhance crop production through various innovative techniques and technologies [11]. Factors such as limited arable land, water scarcity and changing climate pose significant challenges to achieving optimal yields. However, through precision agriculture, farmers can leverage advanced technologies like detecting and optimizing the resource utilization. The second objective is to predict leaf diseases which significantly impact crop health and crop yield.

Early detection and timely intervention are crucial for effectively managing these diseases. Integrating data- driven approaches, machine learning algorithms, and image recognition techniques can aid in leaf disease prediction. By analyzing patterns, symptoms, and environmental conditions, these models can accurately identify and forecast the occurrence of leaf diseases. This proactive approach empowers farmers to implement preventive measures, such as targeted fungicide applications or crop rotations, reducing the impact of diseases on crop productivity. By combining efforts to increase crop production and predict leaf diseases, farmers can optimize resource utilization, reduce yield losses, and promote sustainable agricultural practices. This integrated approach allows for timely decision-making,

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proactive management, and the adoption of appropriate measures to mitigate the risks associated with leaf diseases. Ultimately, it contributes to the long-term sustainability of agricultural systems, ensuring food security and resilience in the face of changing environmental conditions [6].

At to begin with, the data is bunched into a sensible number of bunches, at that point for each bunch has arranged freely byNeural Network (NN). Moreover, as a pre-processing stage a component choice arrange is joined. Nourish forward choice calculation is utilized to find the foremost sensible course of action of highlights for predicting precipitation. To set up the imagination of the proposed cross breed estimate show Convolutional Neural Network (CNN) has been differentiated and two without a doubt caught on models in specific multi-layer perception feed- forward framework utilizing differing execution estimations. Initially, rain fall is predicted for finding the water resource availability in the certain region. Next the soil quality namely PH, nutrition content, nitrogen availability is checked and forecasted through sensor. Through the water and soil data, the required crop for the field is suggested by using neural networks. After that the disease prediction of crop which grown is snapped by digital image processing, picture pre-processing, frequency domain image acquisition, segmentation techniques, including extraction and classification are the most common machine vision techniques [10]. The transformed Image's digital objects are next displayed (or) statistically reported and categorized using classifiers. Digital image processing has advanced at an exponential rate in a variety of industries, particularly in contemporary agriculture

1.1 MACHINE LEARNING

Machine Learning is clearly one of the most powerful and significant technologies in the world today. Machine learning is a technique for converting data into knowledge. Therehas been an explosion of data in thelast 50 years. This massive amount of data is worthless until it is analyzed and uncover the underlying patterns. Machine learning techniques are used to discover useful underlying patterns in complex data that would otherwise be difficult to find. Hidden patterns and problem knowledge can be used to forecast future events and make a variety of complex decisions. Machines must go through a learning process to understand the rules that govern a phenomenon, experimenting with alternative rules and learning from how well they operate [2].

There are multiple forms of Machine Learning; supervised, unsupervised, semi supervised and reinforcement learning. Each form of Machine Learning has differing approaches, but they all follow the same underlying process and theory and the types are supervised learning, unsupervised learning and reinforcement learning [5].

1.2 DATASETS

Machine Learning is strongly reliant on data. It's the most important factorthat allows algorithm training to take place. It gains experience by usinghistoricaldata and information. The higher the quality of the dataset gathering, the higher the accuracy. Data collection is the initial step. There is a need of two datasets forthis project. One is used to model the yield prediction method, while the other is used to forecast the weather. Average Rainfall and Average Temperature for example. These two parameters are anticipated in order to be used as inputs in crop yield prediction. Meteorological API for weather data and Kaggle for crop yield data are the sources of datasets. The sources of datasets are: Weather APIfor weather data and Kaggle for crop yield data.

The yield prediction module dataset requires the following columns: State, District, Crop, Season, Average Temperature, Average Rainfall, Soil Type, Area and Production as these are the major factors that crops depends on. Production is the dependent variable or the class variable.

1.3 DEEP LEARNING

Deep learning is a subset of machine learning that is essentially a three-layer neural network. These neural networks aim to imitate the activity of the human brain by allowing it to “learn” from enormous amounts of data. While a single-layer neural network may produce approximate predictions, additional hidden layers can help to optimize and improve for accuracy. Deep learning eliminates some of the data pre-processing that machine- learning generally entails. These algorithms can ingest and interpret unstructured data such as text and photos as well as automate feature extraction, which reduces the need for human specialists [14].

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Deep learning techniques, on the other hand, are extremely sophisticated, and many types of neural networks exist to solve specific problems or datasets and the models are:

Convolutional Neural Network (CNNs):
It is used primarily in computer vision and image classification applications, can detect features and patterns within an image, enabling tasks, like object detection or recognition.

Recurrent Neural Network (RNNs):
It is typically used in natural language and speech recognition applications as it leverages sequential or times series data.

II. LITERATURE REVIEW

A. CROP YIELD PREDICTION USING MACHINE LEARNING TECHNIQUES:

- It gives an idea of how crop yield is predicted using decision tree Algorithms and Linear Regression. It also involves collecting various parameter such as crop name, season, area, production, soil parameters. The crop yield prediction is a method to achieve a high yield of the crop using previously available data like crop name, season, area, production, soil parameters continuously involve all features that used for high yield of the crop. Selection of features which are necessary for target feature. Some are not precisely considered as a yield, additionally analysis play an important role in the prediction, linear regression approach having two factors response and explanatory variables.
- The proposed system has the following steps for crop yield prediction using linear regression method. The first step is to input an experimental information set, may be the crop information and soil information along with their outcomes. Few techniques will gather, format and organize the information but only the raw information is scarce to figure with the model. Second step is to collect the data and then pre-process the dataset for the junk or noise removal. Third step is to separate the data into training and testing datasets: the information must be partitioned into two datasets.
- The training dataset is having the greatest rate of information, so it will train most of the example datasets to produce the yield. The fourth step is to apply the linear regression on the trained datasets: here the system depends on the complexity of data and also the structure as per the need. Accordingly, the event modeling and the structures are adjusted. Fifth step is to apply the trained linear regression model on the test dataset.[8]

B. TOMATO LEAF DISEASE DETECTION USING DEEP LEARNING TECHNIQUES:

- This approach uses a CNN algorithm to extract hierarchical features based on the input pixel intensity and comparing it with a 26 trained dataset image. Through lowering the inaccuracy across the entire dataset, all the leaf characteristics are optimized. The objective of the paper is to propose a methodology that could classify the tomato leaf diseases and suggest the best solution to overcome the same [9].
- This has been implemented effectively using image processing technique and late on feature extraction for both the input and dataset images to increase the accuracy level of prediction [4].

C. AN APPROPRIATE MODEL PREDICTING PEST/DISEASES OF CROPS USING MACHINE LEARNING ALGORITHMS

- In this section model is made to process the sensor data and get output prediction on plant diseases and pest. Where Raw data is taken from filed and variable is assigned to the data and null, overrange and under range variable is deleted in Data Preprocessing stage. Then this Raw Data is categorizing into Exterior Temperature, Soil Temperature and Soil Sample Dataset. Then this data set is used to predict plant disease and pest in two different flows where data set of Exterior and interior temperature is used to detect the pest and whereas soil samples and exterior temperature used to detect the plant diseases.

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- Flow for Plant diseases: A Sample Data Set of Crops consists of Crop Name, Soil Nutrients like Nitro-gen, Phosphor, Potassium, Zinc, pH value, also Temperature and Humidity required for crops growth is giving as training dataset to Naive Bayes Kernel Model with input with Raw Data set of Soil Samples and 25 Exterior Temperature. Output from this model is pattern comparison of both data set. If pattern is consistent then growth crop is good with no diseases and if it is inconsistent then recall inconsistent pattern and see inconsistent variable, Predict Diseases and apply necessary steps on Crop.
- Flow of Pest Control: A Second Sample Data Set of Crop and Pest consists of Crop name, pest name, optimum temperature of soil and atmospheric temperature helpful to pest and fungus to grow is giving as training dataset to same Naive Bayes Kernel Model with input with Raw Data set of Exterior and Soil Temperature. Output from this model is pattern comparison of both data set. If pattern is inconsistent then the crop is free from pest and If it is consistent then recall consistent pattern and see consistent variable, Predict Pest or fungus and apply necessary steps on Crops [3].

III. PROPOSED METHODOLOGY

The major scope of this project has been to upgrade and automate the irrigation system. Initially, rain is forecasted to determine the availability of water resources in this region. The soil quality, including PH, nutrition, and temperature, is then assessed and anticipated. The suggested approach intends to assist farmersin efficiently managing their agricultural farms with limited resources. In order to construct a smart irrigation system, this system integrates DL characteristics. The crop production analysis system generates results with high productivity for the specified parameters based on matching accuracy and crop name [13]. The (CNN) Model is trained for crop disease prediction, and the system determines if a particular leaf picture is damaged or healthy.

The suggested system is integrated into a single web application, farmers can easily utilize it to estimate the best crop that gives the most yield for their land characteristics, as well as crop health, by just uploading a crop image into the web application. If the crop is harmed, the users are advised to seek treatment for the ailment, relying on the nitrogen, phosphorus, and potassium concentration of the soil, a nutrient management prediction is made.

IV. IMPLEMENTATION

The dataset for this project has been taken from Kaggle site The crop recommendation dataset is having 8 of 8 columns of data, and the fertilizer dataset consists of 23 rows and 8 columns. This dataset consists of about 87 K rgb images of healthy and diseased crop leaves which is categorized into 38 different classes. The total dataset is divided into 80/20 ratio of training and validation set preserving the directory structure The shape (3, 256 256) of the image is the number of channels (RGB) and 256 x 256 is the width and height of the image

CONVOLUTION NEURAL NETWORK MODEL

1. CNNs are designed to capture local patterns and features in images through the use of convolutional layers. This allows them to effectively identify subtle visual cues and textures indicative of specific diseases or abnormalities in plant leaves.
2. Leaf disease symptoms can vary in terms of size, orientation, and position on the leaf. CNNs incorporate pooling layers, which down sample the feature maps, making them less sensitive to variations in location or scale. This translation invariance property is beneficial when detecting diseases across different leaf images [12].
3. CNNs learn hierarchical representations of images by stacking multiple convolutional layers. The initial layers capture low-level features like edges and textures, while deeper layers learn more complex and abstract features. This hierarchical learning enables the model to understand the complex relationships between different parts of the leaf and the presence of diseases.
4. Overall, the CNN models offer powerful tools for analyzing and classifying leaf images, making them a popular choice for leaf disease prediction tasks [1].

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The lists of modules used in this work are:

- Best Crop Prediction module
- Fertilizer Suggestion module
- Crop Disease Identification Module

A. CROP PREDICTION MODULE

This module returns the predicted crop for production based on the user's input. If the user wants to know the production of a crop, the system takes the Nitrogen, Phosphorous, Potassium, Rainfall, City and State details of the user agricultural land as the input as well. The Machine learning model is trained with 23 different crops and each crop is trained with 100 different nutrition parameters [7].

The 23 crops are listed below:

- Rice
- Maize
- Chickpea
- Kidney beans
- Pigeon peas
- Moth beans
- Mung bean
- Black gram
- Lentil
- Pomegranate
- Banana
- Mango
- Grapes
- Watermelon
- Muskmelon
- Apple
- Orange
- Papaya
- Coconut
- Cotton
- Jute
- Coffee

So once the dataset of values like nitrogen, phosphorous, potassium, rainfall, city is trained with the 23 classes of crops processed in the model. When the input is given all the parameters would train back the set given for the mentioned crop. Like each 23 crops would be trained back with all the parameters that are recommended for the module. The algorithmic module which is running back will select like a tree set where for example, if a papaya is chosen And its's range of nitrogen is 45, phosphorous is 78, rainfall is 21, city is Coimbatore and state is Tamil Nadu.So by taking this the module will check for papaya and then the range of all parameters and it will reject the ranges which don't match the crop.

B. FERTILISER SUGGESTION MODULE

This module is used to suggest the farmer on usage of fertilizer based on Nitrogen, Phosphorous, Potassium and crop which user want to grow are given as a input.

There are six classes in fertilizer suggestion:

- N High
- N Low

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- K High
- K Low
- P High
- P Low

So once the dataset of values like nitrogen, phosphorous, and potassium is trained with the 6 classes. When the input is given by the user the 6 classes would range to the data of the trained set specified by each class and algorithmic model will suite the crop to the trained set. So, by taking this the module will suggest the fertilizer for the crop.

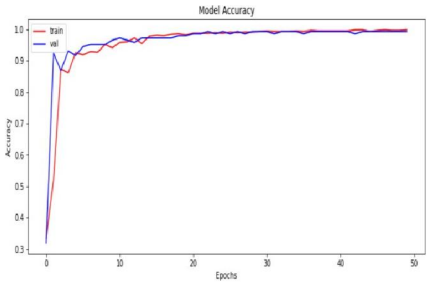
C. CROP DISEASE PREDICTION MODULE

In this module, the user uploads the image of the affected crop and the image is passed to CNN Resnet Algorithm trained model to predict the disease affected to the crop. The predicted disease is displayed in new page of UI. and if no disease is attacked to the crop, it says that the crop is healthy. If the crop is affected it suggests the treatment for the disease [15].

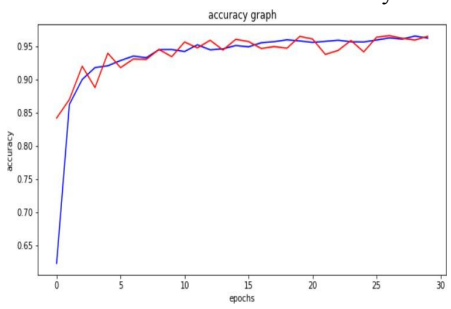
The Deep Learning Model is trained with 38 classes listed below:

Tomato__Late_blight,Tomato_healthy,Grape_healthy
,Orange_Haunglongbing(Citrus_greening),Soybean_
_healthy,Squash_Powdery_mildew,Potato_healthyCorn(maize)Northern_Leaf_Blight,Tomato_Early_bli
ghtTomato_Septoria_leaf_spot,Corn(maize)_____Cercospora_leaf_spot,Gray_leaf_spot,Strawberry_Leaf_scor
ch,Peach_healthy,Apple_Apple_scab,Tomato_Tomato
_Yellow_Leaf_Curl_Virus,Tomato_Bacterial_spot,Apple_Black_rot,Blueberry_healthy,Cherry(including_
sour)Powdery_mildew,Peach_Bacterial_spot,Apple_Cedar_apple_rust,Tomato_Target_Spot,Pepper_bell_
healthy,Grape_Leaf_blight(Isariopsis_Leaf_Spot),Potato_____Late_blight,Tomato_Tomato_mosaic_virus,Stra
wberry_healthy,Apple_healthy,Grape_Black_rot,Pota to_Early_blight,Cherry(including_sour)__healthy,Cor n(maize)
Common_rust,Grape_____Esca(Black_Measles),Raspberry_____healthy,Tomato_Leaf_Mold,Tomato_
Spider_mites,Two_spotted_spider_mite,Pepper,_bell
_Bacterial_spot, Corn(maize)_____healthy

V. RESULT AND DISCUSSION



CNN model architecture accuracy



ResNet algorithm accuracy

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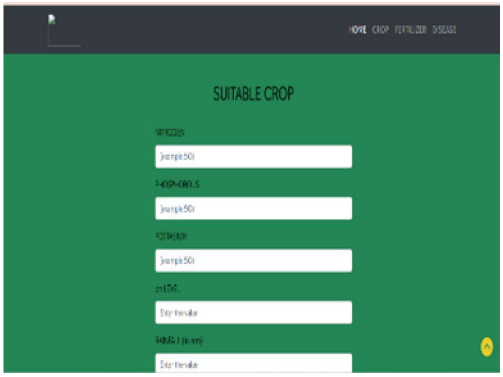
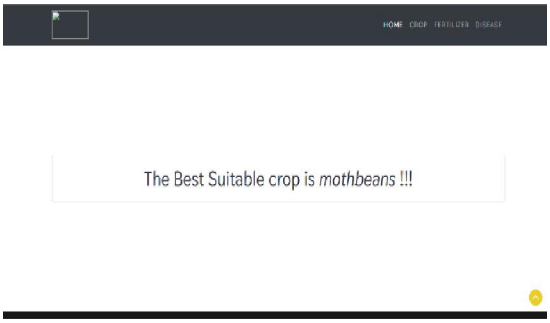
SCREENSHOT OF WEB APPLICATION

MODULE I:

In Crop Prediction, the user enters the Nitrogen, Phosphorous, Potassium, Rainfall, City and State details of the user agricultural land and submits the form. Then the weather condition of the land is fetched using the weather API and the details are passed to the Random Forest and Forest algorithm and suggests the best crop which suits for the given land condition.

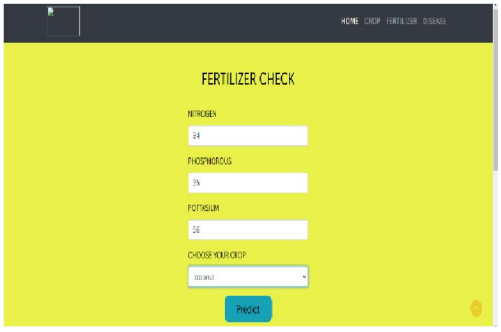


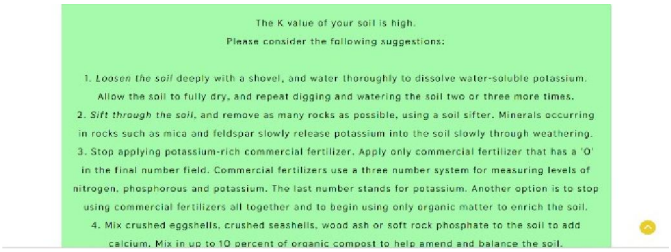


MODULE II:

In Fertilizer Suggestion Page, the user can enter the details of the Nitrogen, Phosphorous, Potassium values of the user land and the values are passed to the algorithm to predict which fertilizer should be used for given land conditions When user gives the input values of the nitrogen, phosphorous, potassium levels with the crop that he/she needs to grow the system gets it and by the trained set of the models it will preprocess it and then will generate the output of which fertilizer is needed or suitable for the user land.

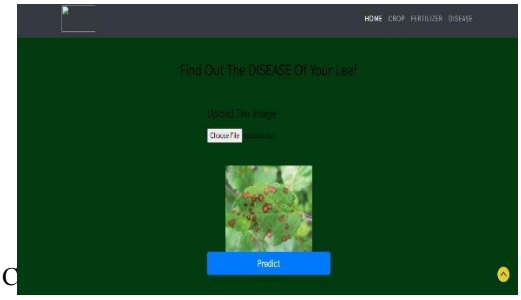
It also gives the suggestion to the user of how he/she should handle it for the production.

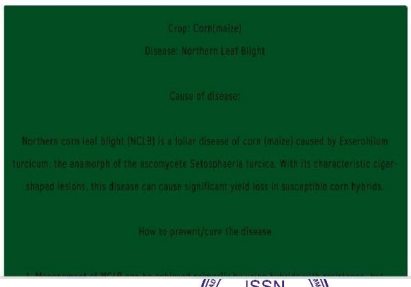




MODULE III:

In leaf disease prediction the user uploads an image and if it is affected it show as diseased crop, in addition to it will also tell the name of the plant, name of the disease, cause of the disease and also the suggestion module. If the module finds there is no disease it will show the user as healthy leaf.





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The module that we have developed has paved the path to increase the crop production by recommending the best crop given by the user and it also gave out the best fertilizer fit by analyzing the soil parameters like nitrogen, phosphorous and potassium. And the leaf disease is predicted by using resnet algorithm. The proposed model is accurate in forecasting which crop will produce the most for the given land environment. This approach assists farmers in determining the crop's health in advance and also increase their growth level by suggesting the best crop and improvising the soil by providing fertilizer suggestion.

VI. FUTURE ENHANCEMENT

- In Future the Nitrogen, Phosphorous, Potassium, PH values are fetched using NPK sensor and the sensors are connected to the Arduino Nano Board and the data is transferred to cloud using GSM WIFI Module and those Realtime data from the sensors are used to get the land condition.
- User Account Future will be added so that user can see their past records.
- As of now the proposed system is developed only as web application and in Future will develop a cross platform mobile application using Flutter
- Currently 38 classes of plant disease are added, in future will add more classes for plant disease. The application will be developed in more user-friendly manner.

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