Detection of Plant Diseases using ResNet50 V2

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Abstract - **Plant disease, deterioration of a plant's normal state (living species) which interrupts, stresses or alters its vital functions. We cannot deny the contribution of agriculture productivity in the Indian economy. That is one of the reasons why plant disease identification plays a vital role in the field of agriculture. Agriculture mainly needs to identify which crop is contaminated. We're indirectly playing a part in improving crop quality with the aid of this research. It is a recognition system focused on deep learning that will support the Indian Economy. Digital crop colour analysis is important because colour change is a rewarding signal for crop health and production. Then it can be assessed using visual measurements and inexpensive crop colour. Artificial Neural Network (ANN), ResNet50 V2, Flask, Adam optimizer will be used in this article.**

keywords - **Agricultural productivity, Flask, RelU, ResNet50 V2, Adam optimizer, Keras.**

I. INTRODUCTION

Plant diseases pose a major threat to food security and food quality, but in many parts of the world their identification remains difficult due to the lack of the necessary infrastructure. Plant diseases are not only a threat to global food security but can also have adverse effects on small farmers whose livelihoods depend on safe crops. In the developing world, small farmers produce more than 80 percent of agricultural production, and reports of yield losses of more than 50 percent are common due to pests and diseases. A large fraction of hungry people (50%) lives in small-scale farming households, making them particularly vulnerable to pathogen-derived food supply interruption.

Numerous plant diseases can be classified based on the pigment, size, shape, growth, and structure of the plant. But these observations can be only done by a farmer or someone with knowledge in this field. But with the lack of time and facilities pathogens affects the plants quite much.

The spray of pesticides is harmful and toxic which leads to a decrease in plant species. Rather it helps to cure the spread of pathogens in other plants. Therefore, there is a need for modern technologies that can easily identify plant diseases without human aid.

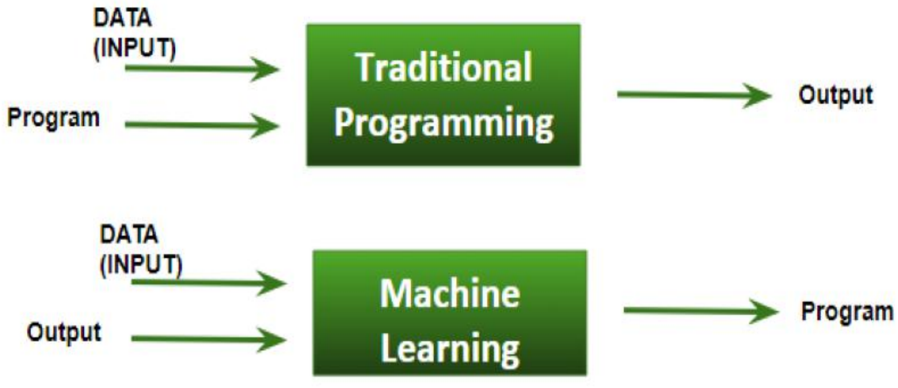

Fig. 1.Data Processing Using Machine Learning

With the increase in global Smartphone penetration and recent upgrading techniques in machine learning made it possible for Smartphone-assisted disease diagnosis. To improve the recognition rate and the accuracy of the tests, modern methods such as machine learning and deep learning algorithm were employed. Various research has been carried out in the field of machine learning for the identification and diagnosis of plant diseases, these conventional machine learning techniques include random forest, artificial neural network, support vector machine (SVM), fuzzy logic, K-means method, convolutional neural networks, etc.…

Support Vector Machine

A Support Vector Machine is a supervised model of learning which uses classification to find hyperplane in N-dimensional space. A Support Vector Machine is basically helpful in separating data of different classes of data. In a two-dimension space, a line acts as a separator between two different classes.

For example: Suppose data of two different types of vegetables are given in for a plot. The Support Vector Machine considers the data and helps to separate the data by line. This line is created by considering the distance between the points of different classes. Several factors affecting the type of the line are: kernel, regularization, gamma and margin values.

layman term SVM optimization can be written as,
if $y_i(w.x_i+b)-1=0:$
then (x_i, y_i) *is support vectors*
then save the parameters w, b
else if $y_i(w.x_i+b)-1>0:$
then save the parameters w, b
else if $y_i(w.x_i+b)-1<0:$
then update the parameters w, b

K-Nearest Neighbours

K-nearest neighbours are the most basic supervised learning algorithm that is used in machine learning to solve different regression and classification problems. In regression problems, the KNN algorithm predicts a real number as the output. Whereas the KNN algorithm can also be used to classify data and it gives a discrete number as its output.

The KNN algorithm makes an assumption that similar things are near to each other. With each point on the map, the KNN algorithm uses brute force techniques to measure the Euclidean distance from the input test point. Hence it can predict whether the test point will lie in either class. It is a slow approach and takes more time to classify the data.

$$(DP,q) = \sum_{i=1}^{n} (q_i - p_i)^2 \quad \ldots\ldots (1)$$

Naïve Bayes

Naïve Bayes algorithm is an efficient supervised learning algorithm that uses the Bayes Theorem with the "naive" conditional independence assumption over the training set. It does not use a single algorithm but uses different that follow the same principle i.e. every pair of features fed to the algorithm is independent of each other.

The simple formula of the Bayes Theorem is

$$P(A/B) = \frac{P(B/A)\,P(A)}{P(B)} \quad \ldots\ldots (2)$$

The Naïve Bayes algorithm uses this formula as the parent to find predictions.

K Means Clustering

Clustering is essentially a type of unsupervised model of learning and is grouping objects on the basis of similarity and difference. It can be described as the task of identifying subgroups in the data, such that data points are very similar in the same subgroup (cluster) while data points are different in different clusters.

K-Means algorithm is an iterative clustering algorithm in which data sets are partitioned into predefined K subgroups (clusters) in which each data point belongs to a single group only. This algorithm categorizes the data items into similar K-groups. Euclidean distance is used in this model. The data is iterated over the Euclidean distances of the points and with the help of its mean, the data is clustered.

$$J = \sum_{j=1}^{K} \sum_{n \epsilon S_j} |x_n - \mu_j|^2 \quad \ldots\ldots (3)$$

Random Forest

Random Forest is a supervised learning algorithm that mainly uses classification but also regression. A forest is made up of trees and the number of trees gives accurate results. Similarly, decision trees are created on datasets using a random forest algorithm and then get the prediction from each decision tree and finally, the best solution is selected through voting. It is better than a single decision the tree because it reduces the over-fitting by taking an average of result.

It is unexcelled in accuracy among current algorithms. It runs efficiently on large databases. The random forest has less variance than the single decision tree. Scaling of data don't require in random forest algorithm. It maintains good accuracy even after providing data. Chebyshev inequality:

$$|x - \mu| \geq k$$

Convolutional Neural Networks

Image classification defines image objects and label the images as a dataset of raw pixels. CNN is a type of neural network model that allows us to extract higher representations for the image content. Unlike the classical image recognition where we define the image features ourselves, CNN takes the image's raw pixel data, trains the model, and then extracts the features automatically for better classification

ReLU and Softmax

Activation functions are the functions that are implemented to determine the output of a neural network. These are basically used to statistically balance the data (usually between 0,1 or -1,1).

A Rectified Linear Unit has an output 0 if input less than 0, and a raw output otherwise.

$f(x)=max(x,0)$

A Softmax function gives output in the range [0,1] and maps the outputs in the range such that their sum is equal to 1.
It is therefore a probability distribution.

$$\sigma(\mathbf{z})_j = \frac{e^{z_j}}{\sum_{k=1}^{K} e^{z_k}} \quad \text{for } j = 1, \ldots, K.$$

Keras

Keras is an open source library that acts as an interface for the artificial neural networks. It also has support for convolutional and recurrent neural networks.
It supports utility layers like batch normalisation, pooling, padding, dropout, etc. And necessary layers like activation, optimization, objectives.

Transfer learning

Transfer learning (TL) : A research problem in machine learning (ML) that focuses on storing knowledge gained while it solves one problem and applies it to a different but similarly related problem.

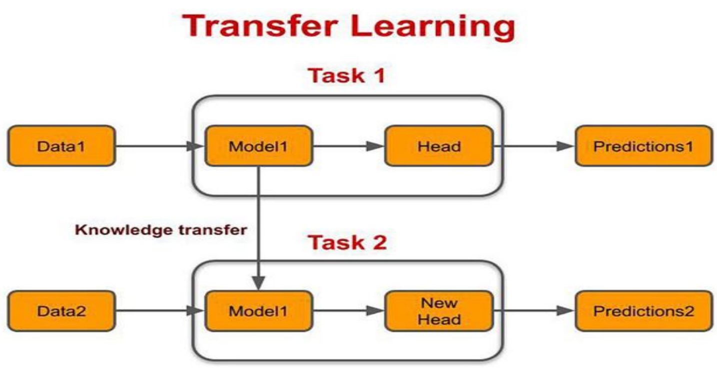

Fig. 2. Transfer Learning Model

Max Pooling

Pooling layers provide an approach to down sampling feature maps by summarizing the presence of features in patches of the feature map. Maximum pooling, or max pooling, is a pooling operation that calculates the maximum, or largest, value in each patch of each feature map.

Batch Normalisation

In order to normalize the data, we subtract the mean and divide by the standard deviation.

$$z = \frac{x - \mu}{\sigma}$$

$\mu =$ Mean
$\sigma =$ Standard Deviation

It's common to normalize the pixel values of every image before training. Batch normalization, on the opposite hand, is employed to use normalization to the output of the hidden layers.

Conv2D

The Residual module in the ResNet architecture uses 1×1 and 3×3 filters as a form of dimensionality reduction which helps to keep the number of parameters in the network low.

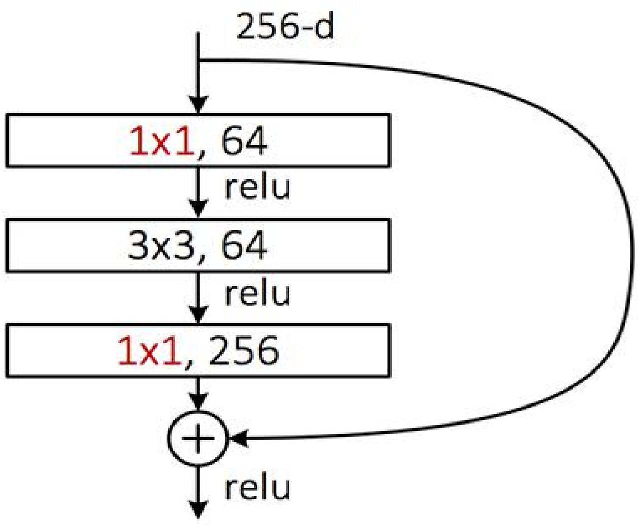

Fig. 3. 2D Convolution Layer

ResNet50 V2

The architecture of ResNet50 has 4 stages. It can take input as images of height 32 and 3 as image width. For each residual function ***F,*** 3 layers are stacked one over the other. The three layers are 1×1, 3×3, 1×1 convolution. The 1×1 convolution layers are liable for reducing and then restoring the dimensions. The **3×3** layer is left as a bottleneck with smaller input/output dimensions.

Adam Optimizer

This optimizer can be used in place of the classical stochastic gradient optimization. Unlike the later Adam does not have a static learning rate and hence updates regularly with respect to the data.

It has both the functions of Adaptive Gradient Algorithm and Root Mean Square Propagation.

II. LITERATURE SURVEY

The main objective of the literature survey is to analyze the latest research in the agricultural field using machine learning techniques. This is the study of the collections of key research collections in the new design process. This approach coincides with the current practice of research. Various researchers have carried out significant work in the same field.

Rumpfa T. et al. [1] (2010) Using the Support Vector Machine (SVM) algorithm identify and describes plant diseases. The accuracy of the classification of safe leaves was nearly 87% and exceeded > 95%. Leaves inoculated with C. Beticola were correctly diagnosed by SVMs with an accuracy range of 65% to 80%, even before symptoms became evident. SVMs proved an effective automated classification tool. After making use of all the features they were able to obtain an accuracy of 90%.

Badnakhe Mrunalini R. and Deshmukh Prashant R. [2](2011)said that "There are two main characteristics of plant-disease detection machine-learning methods that must be achieved, they are: speed and accuracy." They used a concept that implemented the framework of the image processing technique using k-means clustering. The framework was divided into several different steps:

1) Image pre-processing
2) Image acquisition
3) Classification based on classifiers
4) Statistical Analysis
5) Image segmentation
6) Extraction of Features
7) Classification based on classifiers

In the future, the experimental results suggest that the proposed method is a successful approach, which can in a limited computational effort substantially help accurate identification of a root, leaf and stem disease. But the effort is quite a tedious one. It requires a lot of computer memory and time to process accurate results.

Akhtar Asma et al. [3] (2013) use the MATLAB software for experimentation of the proposed system. We found that the Decision tree acts as the best classifier followed by KNN and SVM. They made use of a combination of SVM, DWT, and DCT. The best accuracy was found out to be near 94.45%. Although this percentage does not give the best results because we can improve upon this algorithm by focussing more on image processing and classification.

Kaur Rajleen [4] (2015) suggested a Support Vector Machine (SVM) algorithm and an ANN-based algorithm. They made use of two databases, namely data training and testing. They were using the masking images concept. This algorithm first takes an image that is in RGB form. The enhanced SVM algorithm performed way better than the existing SVM algorithm, giving results at an enhanced rate of 72% as compared to the traditional rate of 65%.

Naik M. Ravindra et al. [5] (2016) presented the technique of Image segmentation which is an important aspect of the identification of diseases in plant leaf disease and is performed using a genetic algorithm. This paper used a new classification model involving SVM, neural networks (NN) and genetic algorithm (GA) that were used to build a computer-based vision system for automatic plant species identification and related diseases.

They used 5% of the leaf images to train the system and the rest of them were used as testing datasets. The accuracy using SVM came out to be 86.77% and that using the NN classifier was 95.74%. This algorithm used very less computational efforts to produce accurate results though it was also reviewed that as the size of datasets increased the percentage of accuracy decreased.

Mengistu Abrham Debasu et al. [6] (2016) studied the basic plant diseases in the specific field of coffee plants. Coffee beans are grown particularly in a great amount in Ethiopia. The main plant diseases in coffee plants are Coffee Berry Disease (CBD), Coffee Leaf Rust (CLR) and Coffee Wilt Disease (CWD).

They made use of four types of classifiers (Naïve, combination of RBF and SOM, ANN and KNN) for Ethiopian coffee plant diseases. It was concluded that RBF and SOM combined have better performance than the other classifiers. But it took a long time for RBF and SOM to combine to be trained. Also, they studied only about the leaves of the plant and hence recommended to study about the stems and roots of the plant. The accuracy result of Naïve and a combination of RBF and SOM, ANN and KNN are 53.47%, 90.07%,58.16 %, and 79.04% respectively.

Badage Anuradha [7] (2018) used two phases, where the first phase was used for training of the datasets and later when the datasets were trained they were then used for extracting the threshold values for the aging of the diseases. The trained model uses the dataset to provide proper suggestions and makes use of the Canny Edge Detection Algorithm. Crop diseases are detected at an early stage by using edge detection and histogram matching.

This algorithm makes use of a double threshold checking process which makes it a tedious process. Since it is divided into a 5-step process overall, it proves to be an efficient algorithm to detect plant diseases.

Ramesh Shima et al. [8] (2018) used a Histogram of an Oriented Gradient (HOG). Ultimately, using machine learning to train the large data sets that are publicly available gives us a simple way to detect a colossal scale of the disease present in the plants.

The histogram of oriented gradients (HOG) is an element descriptor used for object detection as a part of PC viewing and image processing. Here, they used descriptors of three components: 1. Hu minutes 2. The texture on Haralick 3. Color Histogram.

The algorithm here is implemented using a random forest classifier. We are inherently versatile. The model was trained using 160 images of papaya leaves, using a random forest classifier. The model could rank with an accuracy of approximately 70 percent. Though this algorithm gave high accuracy results when the number of datasets was increased but it proves to be less accurate when handled with a low number of datasets.

Kaur Narinder et al. [9] (2019) described the image segmentation procedure for the portioning of a picture into displaced sections. Their study includes the use of GLCM (Gray Level Co-occurrence Matrix) to determine texture characteristics. And k-means clustering for the area-based segmentation of the plant diseases. They used 60% of data for training of the dataset whilst 40% was used for testing of the system. After testing it was concluded that the proposed approach shows precision nearly about 97%.

III. LIMITATIONS OF EXISTING WORK

By reviewing the literature, we found that there are some problems still existing with the initial evaluation system mentioned in the problem induction.

Few types of research found that the Combination Gray Level Co-occurrence Matrix Algorithm and K-Means Clustering in Diagnosis is the most suitable technique for the prediction of plant disease. All research needs databases like image datasets of plants and the corresponding diseases that are associated with the respective plants. The availability of the previous results of the traditional algorithms helps us to enhance the new algorithms that will help to make the systems more effective and accurate.

The data set provides prior knowledge of disease and its functionalities. Many chronological diseases still exist in the present diagnostic system that is not able to characterize the specific diseases. The system is lacking statistical tools in pre-processing of training data or symptoms which create difficulty for non-expert plant scientists to understand it (system) properly.

Few researches showing greater accuracy do not seem to have tested a large amount of data and hence cannot be relied upon for surety.

Table 1: Complete Details of the Cited Papers

Author Name	Title of the Paper	Year	Techniques	Used Data	Accuracy
T. Rumpf et al	"Early detection and Classification of plants with Support Vector Machines based o hyperspectral reflectance"	2010	"Support Vector Machine (SVM)"	"15 sugar beet plants in each group"	90%
Mrunalini R. Badnakhe and Prashant R. Deshmukh	"An Application of K-Means Clustering and Artificial Intelligence in Pattern Recognition for Crop Diseases"	2011	"K-means Clustering"	"The digital images acquired from the environment referring sites."	N/A

Asma Akhtar et al	"Automated Plant Disease Analysis (APDA): Performance Comparison of Machine Learning Techniques"	2013	"Decision tree"	40 images of rose leaf samples."	94.45%
Rajleen Kaur	'An Enhancement in Classifier Support Vector Machine to Improve Plant Disease Detection "	2015	"Support Vector Machine (SVM) algorithm and ANN"	"RGB Images"	72%
M. Ravindra Nayak et al	"Plant Leaf and Disease Detection by Using HSV Features and SVM Classifier"	2016	"Genetic Algorithm (GA) and Neural Networks (NN) "	10 species of the plant leaf."	95.74%
Abrham Debasu Mengistu et al	Ethiopian Coffee Plant Diseases Recognition Based on Imaging and Machine Learning Techniques"	2016	"ANN, KNN, Naïve, and combination of RBF and SOM"	9100 coffee plant diseases image from regions of Ethiopia"	90.07%
Shima Ramesh et al	'Plant Disease Detection Using Machine Learning"	2018	"Histogram of an Oriented Gradient (HOG)"	"160 images of papaya leaves"	70%
Anuradha Badage	N/A	2018	Canny Edge Detection Algorithm"	"Healthy and diseased leaf images."	N/A
Narinder Kaur et al	"Classification and Segmentation Approach for Plant Disease Detection"	2019	GLCM (Gray level co-occurrence matrix)	10 normal and 30 infectious potato leaves."	97%

IV. PROPOSED METHODOLOGY

Digital cameras or similar devices are used to take images of leaves of different types, and then those are used to identify the leaf and type of disease they are having. Then different types of image-processing techniques are applied on them, to process those images, to get different and useful features needed for the purpose of analysing later.

Algorithm written below illustrated the step by step approach for the proposed image recognition and segmentation processes:

- Image acquisition is the very first step that requires capturing an image with the help of a digital camera.
- Here Flask is used to host the webpage and supply images to the Deep Learning model.
- Pre-processing of input image to improve the quality of image and to remove the undesired distortion from the image. The image is loaded in the RGB mode and is resized to a desirable shape (i.e. 224,224).
- The image is loaded a numpy array and fed to the Neural Network for predictions.
- For making predictions, Convolutional Neural Networks along with Transfer Learning is used.
- Transfer Learning is a method of training pretrained models using our custom datasets.
- After the neural network model tries to extract similar features in the test image and tries to make a prediction.
- The labels are then extracted from the predictions and output is supplied to the webpage using Rest API

V. RESULT

Using a public dataset of 54,306 images of diseased and healthy plant leaves collected under controlled conditions, we were able to identify 14 crop species and 26 diseases (or absence thereof) with a Training accuracy of 99.37% and Testing accuracy of 96.10%.

VI. CONCLUSION

In our investigation, it was found that with the help of advancements in the machine learning technologies we can make our systems perform better. We can enhance the work by combining the most effective techniques with another classifier of a neural approach. Studies and coming up with new techniques in the field of Deep Learning in the near future might help achieve the highest accuracy.

Using our methodology of Transfer learning (implementing Resnet50 V2) we were able to achieve an accuracy of ~96%.

We can hence conclude that using deep learning and transfer learning techniques we are able to achieve a higher accuracy with respect to previous researches made in the same field of interest.

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