GREEN GUARDIAN: PLANT DISEASE DETECTION SYSTEM

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***Abstract*: The identification of plant disease become digitalized and data-driven, enabling advanced support, smart analyses, and planning. This paper proposes a model of plant disease detection and solution based on deep learning, which improves accuracy, and training, and provides a solution to said disease. We are using the deep learning-based approach for image recognition to detect plant diseases. We have examined the main Architecture of the Neural Network: Convolution Neural Network. This model examines diseases like Black Rot, Cedar Apple Rust, Leaf Blight, etc. The current results show the accuracy of the method around to be very high, which is better than traditional methods, thus reducing the influence of disease on agricultural production and being favorable to the sustainable development of agriculture. Therefore, the deep learning algorithm proposed in the paper is of great significance to intelligent agriculture, ecological protection and agricultural production, and general convenience.**

***Keywords*: plant disease recognition, deep learning, computer vision, convolutional neural network**

INTRODUCTION

Early plant disease detection plays a very significant role in efficient crop yielding. Plant diseases like black measles, black rot, bacterial spot, etc. affect the growth, crop quality of plants, and economic impacts on the agriculture industry. To avoid the impact of diseases, costly approaches and the use of pesticides are some solutions the farmers usually implement. The use of chemicals means damages the plant and the surrounding environment. In addition, this kind of approach intensifies the cost of production and major monetary loss to farmers. Early discovery of diseases as they occur is very important for efficient disease management. Manual disease detection through human experts to identify and recognize plant diseases is a usual practice in agriculture. With the improvements in technology, automatic detection of plant diseases from raw images is possible through computer vision and artificial intelligence research. In this study, we were able to investigate plant diseases and pest infestation that affects the leaves of the plants. Today's better technologies are enabling people to provide the adequate nutrition and food needed to meet the needs of the world's growing population. If we talk about India unequivocally, the majority of the Indian people are directly or by a stretch related to the cultivating territory, which remains the greatest region in the country. If we explore the broader Picture According to Research Conducted, overall yield creation can be augmented at any rate half putting more weight on the inside and out pushed and cultivating Sector. “Green Guardian” is a web-based system that will be developed using Deep Learning algorithms/techniques.

The purpose of building this project is to create a system using a technology that can allow the users to detect whether their plant has a disease or not and provide the remedy for it at their own convenience. Recently, Deep Learning has led to great performance in various fields like Image and Speech Recognition, and Natural Language Processing. The use of the Convolutional Neural Network in the Problem of Plant Disease Detection has shown good results.

MOTIVATION

In the Indian economy, most the rural households depend on agriculture for their livelihood but leaf infection phenomena cause the loss of major crops resulting in economic loss. Leaves are a delicate part of the plants, so they should be tested via non-destructive techniques.

For this reason, it is very important to determine the disease at an early stage and take necessary precautions to prevent ruining of crops or spreading to other crops. Therefore, this system is suitable for farmers or simply those who want to detect disease in plants. The agronomic requirements though in radically different ways to those currently used this has given rise to many new changes to service. Hence, classification of diseases is necessary for the evaluation of agricultural produce, increasing market value and meeting quality standards.

RELATED WORK

1. Sammy. M, Bobby. G, et.al in [1] proposed a system with a goal of detecting and recognizing 32 different plant varieties and plant diseases using convolutional neural network. The trained model can be used to test real-time images to detect and recognize plant diseases. With the achieved accuracy of 96.5%, the proposed model can assist farmers to detect and recognize plant diseases.
2. J. Nithiswara Reddy, Karthik Vinod, et.al in [2] proposed a system which used k-mean clustering algorithm to segment and analyze the infected region of the leaf. The choice of selection of the number of clusters is user dependent. The images are fed to our application for the identification of diseases. It acts as an efficient system in terms of reducing clustering time and the area of the infected region.
3. M. P. Vaishnnave, K. Suganya Devi, et.al, in [3] proposed a system which focused on groundnut crop diseases like Early leaf spot, Late leaf spot, Rust, early and late spot Bud Necrosis. The system categorized only 4 dissimilar diseases with efficiency.

The examination work decreased the false classification by using extra classifiers for feature extraction among the various groundnut crop diseases.

4. Md. Arifur Rahman, Md. Mukitul Islam, et.al, in [4] proposed a method of system which focuses on improved segmentation approach for plant leaf disease identification. It is an effective segmentation technique and doesn't require any kind of heavy computational power. However, there is a scope to improve work in the future by reducing feature vector size as well as keeping the classification accuracy higher.

CONVOLUTIONAL NEURAL NETWORK

A Convolutional Neural Network (CNN) is a type of neural network used in image recognition, and processing that is specifically designed to process pixel data of a given image.

1. Convolutional Layer

Convolutional layers store the output of the kernels from the previous layer which consists of weights and biases to be learned. The generated kernels that represent the data without an error is the point of the optimization or loss function. In this layer, a sequence of mathematical processes is done to extract the feature map of the input image.

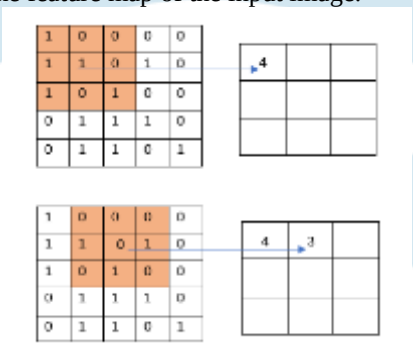


fig 1. Illustration of convolutional layer

2. Pooling Layer

This layer reduces overfitting and lowers the neuron size of input image for the down sample the layer. It illustrates an example of the pooling operation. This layer reduces the dimension of input image by reducing the parameter numbers, training-time, computation rate and controls overfitting.

fig 2. Illustration of pooling layer

3. Activation Layer

Utilizes a non-linear ReLU (Rectified Linear Unit) activation layer in every convolution layer. The application of dropout layers to prevent overfitting is also applied in this layer.

4. Fully Connected Layer

This layer is also called as Dense layer. It is also used to analyze the class probabilities and the output is the input of the classifier. Softmax classifier is the well-known input classifier and recognition and classification of plant diseases are applied in this layer.

Algorithm

Steps for CNN algorithm:

1. Start
2. Pass the Image (224,224) to the model from the input layer which consists of input neurons.
3. The output of the input neurons passes the Image to hidden layers i.e., Convolutional layers.
4. Pass Image from Convo layer to Pooling layer conduct Max Pooling operation to reduce the dimension.
5. In Activation layer, if the value of the Image from previous layer is negative then it termed the value 0 or if its positive then it passes the value to next layer.
6. The value of Image from previous layer (Activation layer) is passed on to Fully Connected layer i.e., Output or Dense Layer. The 38 classes will be considered and the input of activation layer will be converted into an output acceptable by SoftMax Classifier.
7. SoftMax Classifier converts the values of output from previous layer into binary value.
8. Stop.

Steps for ResNET Model:

1: Start
2: Pass the Image (224,224) to the Resnet model
3: Adding the Pre-processing layer in the front of the Resnet model for input
4: Freezing the weights by not allowing the Resnet layer to train
5: Adding the Dense layer by specifying the activation classifier and Flatten layer for an output
6: Creating a model with passing the input and output
7: Compiling the model by specifying the learning rate, loss, and metrics as accuracy
8: Adding the Augmentation techniques
9: Adding the Early Stopping and Model Checkpoint
10: Fitting the model (Training the model)
11: Stop

Mathematical Concepts

1. Binary Cross Entropy

It is known to a be a loss function and it minimizes the difference between actual value and predicated value. It compares the each of the predicated values to actual outputs which can be either 0 or 1.

$$logloss = -\frac{1}{N}\sum_{j}^{N}\sum_{j}^{M} y_{ij}[\![log(p]\!]_{ij})$$

- N = Number of rows
- M = Number of classes
- Y = Target values
- P = predicted values

2. SoftMax Activation Function

The SoftMax function is used as activation function in the output layer of neural network model that consists and predicts multinomial probability values.

$$\boldsymbol{\sigma}(\vec{z})_i = \frac{e^{z_i}}{\sum_{j=1}^{K} e^{z_j}}$$

- σ = SoftMax
- $\vec{z}$ = Input vector
- e^{z_i} = Standard exponential function for input vector
- K = Number of classes in the multi-class classifier
- e^{z_j} = Standard exponential function for output vector

3. Forward Propagation

Forward propagation sequentially calculates and stores intermediate variables within the computational graph defined by the neural network. It proceeds from the input to the output layer.

$$Z[l] = W[l].\ A[l-1] + b[l]$$
$$A[l] = g[l]\ (Z[l])$$

4. Back Propagation

Backpropagation sequentially calculates and stores the gradients of intermediate variables and parameters within the neural network in reversed order.

$$dZ^{[l]} = dA^{[l]} * g'(Z^{[l]})$$
$$dA += \sum_{m=0}^{nh}\sum_{n=0}^{nh} W.dZ[m,n]$$

- Z = input image
- W = weight
- A = activation output
- b = bias

- g = gradient
- [l] = current layer
- [l-1] = previous layer

Proposed Approach

Image Acquisition –

The image taken from a controlled environment is converted from optical format (real-world image) into numerical data which later be manipulated by the model for prediction.

Data Preprocessing -

The collection of data is the initial step. The dataset we worked on consists different types of plants and their diseases. In order to exploit this model under a real-time scenario, there are thousands of plants images we're dealing with, such as Cherry, Grapes, Apples, Tomato, Potato and Strawberry etc.

We are using New Plant Dataset and it consists approx. 87,000 Images. It also consists healthy and unhealthy plant images.

- Dataset

Dataset	Healthy	Unhealthy
87,867 Images	22,721	65,146

Image Segmentation –

Image segmentation is the task of clustering parts of an image together that belong to the same object class. This process is also called pixel-level classification. In other words, it involves partitioning images (or video frames) into multiple segments or objects.

Feature Extraction –

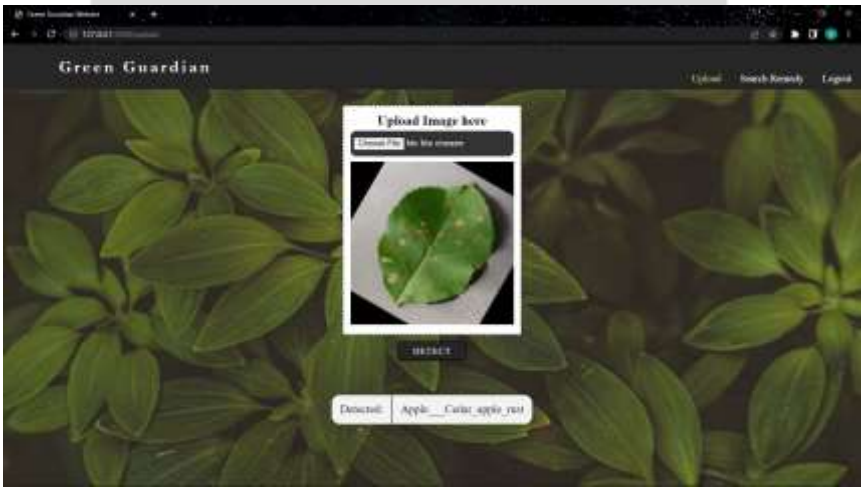
Feature extraction is a dimensionality reduction process, in which, an initial set of the raw data is divided and reduced to more manageable groups. So, when you want to process it will be easier.

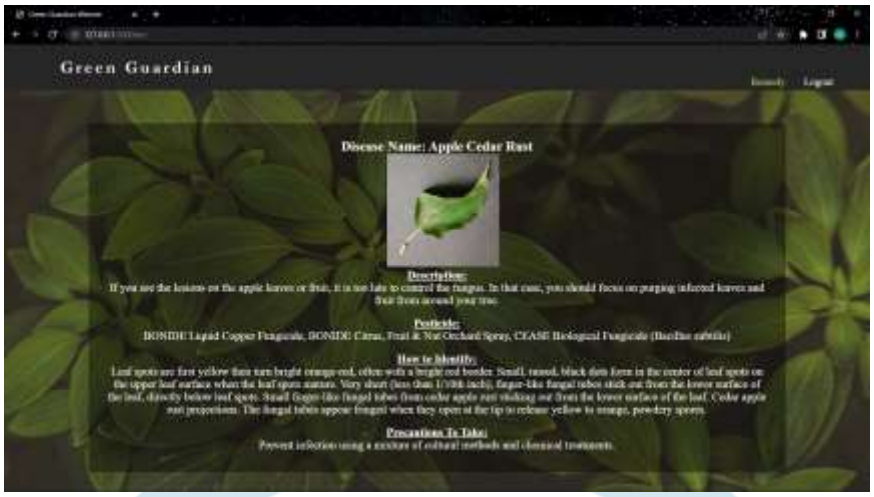
Transfer Learning

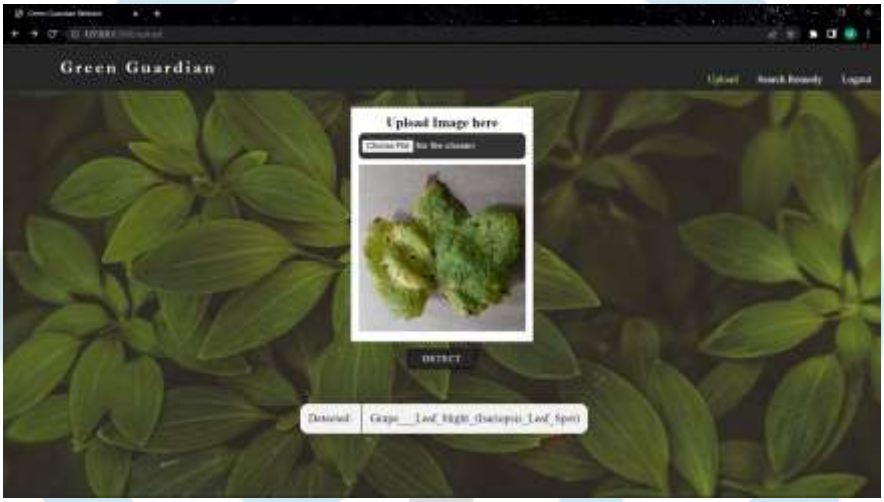
The reuse of a pre-trained model on a new problem is called "Transfer Learning". This "Transfer Learning" is an optimization technique that improves the performance when modeling the second task. The improvement of learning the new task is done through the concept of learning over a related task that has already been learned on.

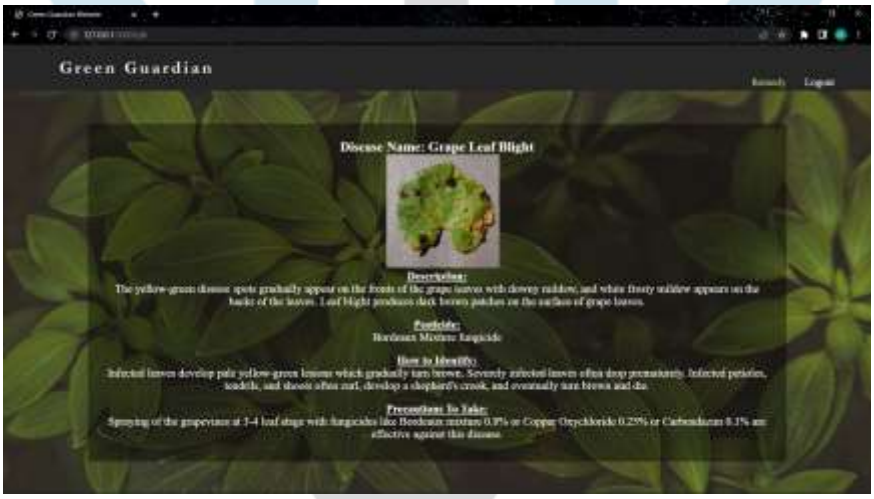
We are using the ResNet 152 application provided by Keras API as the model of our choice for Transfer Learning. ResNet is a pre-processed deep neural network consisting of up to 152 layers. The learning in it is done by the unused representation functions instead of learning the signal representation directly. ResNet became the winner of ILSVRC 2015 in image classification, detection and localization, as well as winner of MS COCO 2015 in detection and segmentation earlier. ResNet introduces "skip (or shortcut) connection" to fit the input from the previous layer to the next layer without any modification of the input and later a fully connected/ dense layer is added according to its given output in model.

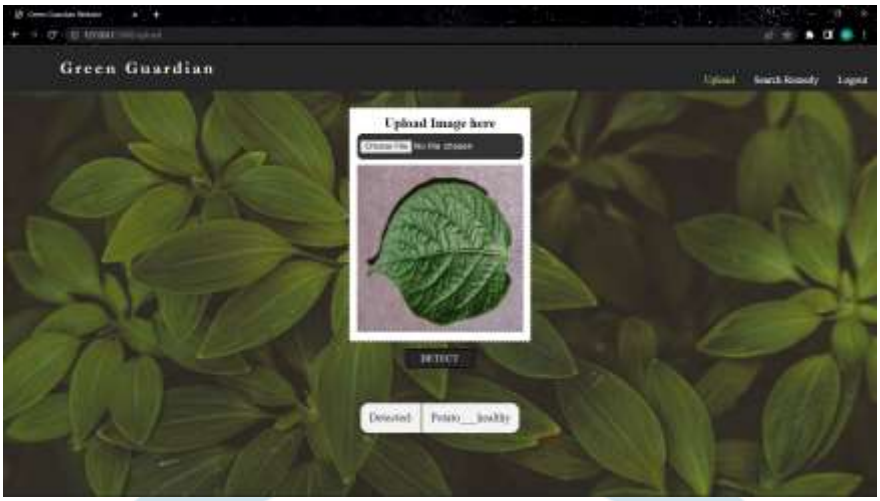
Results




Green Guardian
Disease Name: Apple Cedar Rust
Description:
Pesticide:
How to Identify:
Precautions To Take:


Green Guardian
Upload Image here
DETECT
Detected


Green Guardian
Disease Name: Grape Leaf Blight
Description:
Pesticide:
Bordeaux Mixture fungicide
How to Identify:
Precautions To Take:



Future Scope

Currently, the model is able to detect 26 types of diseases with an average detection time of 9.5s. If we choose to go for a more robust or faster neural network (e.g., YOLOv3, FRCNN) we will be able to widen our detection range while increasing detection accuracy and reducing the average detection time. A better neural network would allow us to add features like real-time leaf detection and make detection in a dimmer or less curated environment possible. We can add a simple auto-translation module that will translate the website to different languages (e.g., Hindi or Marathi) making it accessible to a wider audience.

Conclusion

The system "Green Guardian" achieves its goal to detect and recognize different plant diseases using a convolutional neural network and achieves an accuracy rate of 94%. Green Guardian aims to find appropriate features that can identify leaf disease.

Firstly, healthy and diseased leaf images are collected and pre-processed. Then, characteristics of the shape, color, and texture are extracted from these images. After that, these images are processed by the algorithm and other techniques resulting in a high classification accuracy of disease. Green Guardian is robust enough to detect diseases from images on the internet and/or images taken from a camera. At last, the Green Guardian will provide remedies for the particular plant disease.

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