Deep Learning-based Tomato Leaf Disease Detection and Pesticide Suggestion Platform for Farmers

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**Abstract~** Depending on the amount consumed daily, tomatoes are regarded as a well-cultivated and profitable crop. The tomato plants were infected by a number of viruses, with leaves being the main site of infection for the other plant components. The likelihood of a virus spreading to nearby plants in the field is very high. This will make it difficult to grow tomatoes. Farmers are looking for a useful technology or approach that can forecast the kind of illnesses and the virus that causes such illnesses. And that approach must give farmers instructions or advice for the appropriate insecticides to employ in order to stop virus infection. A website has been created that uses deep learning to identify tomato leaf disease and suggests the best pesticide using a database management system. Using a convolution neural network, nearly 10 distinct diseases that affected leaves were detected and categorized. The accuracy in diagnosing the disorders is between 94% and 98%.

 I. INTRODUCTION

 The tomato plant, Solanum lycopersicum, commonly referred to as the tomato plant, yields the tomato, an edible berry. The tomato plant has just one growing season before being harvested and can grow to a height of 0.7-2 m (2.3-6.6 ft). Tomatoes are relatively easy to grow, so most household can get by with just a few plants. Even in the peak times, the quality of fruit that is plucked from the garden when it is fully ripe is far superior to anything that is bought from a store. The final plant height and cultural requirements are decided by which of two tomato plant kinds is used.

 II. OBJECTIVE

The goal of the project, "Deep Learning-based Tomato Leaf Disease Detection and Pesticide Suggestion Platform for Farmers," is to create an accurate and user-friendly system that uses deep learning methods to accurately identify diseases in tomato plants based on leaf photographs. The platform will additionally offer effective insecticides to help farms fight the diseases found. To accurately identify and classify common diseases that affect tomato plants, such as tomato yellow leaf curl virus, early blight, late blight, bacterial spot, and others, build a deep learning model. To train the computer, a vast library of images of tomato leaves with annotation that represent different disease stages will be employed. Add a pesticide suggestion feature to the platform based on the assessment. This component ought to offer information on the appropriate pesticides to use, how to utilize them, and the suggested dosages in order to treat the diseases that have been identified. The guidelines should take into variables including disease severity, environmental variables, and local laws.

 III. EXISTING METHODS

### Different image-based feature extraction techniques were used in earlier approaches to classify tomato leaf diseases, and the results were fed into classifiers powered by machine learning.

### Support Vector Machine

### Stability Vector Machines algorithm for supervised learning The machine learning algorithm known as Support Vector Machine, or SVM for short, is used to solve classification and regression issues. Applying SVM, each tomato leaf image is plotted as a point in n-dimensional space, with each value of the attribute being the value of a particular coordinate. This study is concerned with the classification of tomato plant leaf diseases. The photos are then appropriately classified using these attributes' hyperplane separation.

### Random Forest

An ensemble model called Random Forest is made up of several decision trees. This is a very trustworthy technique that determines negatively correlated trees to outperform single models and randomly samples training data to prevent overfitting.

**Xtreme Gradient Boost**

Gradient-boosted decision trees can be implemented with increased performance thanks to the open-source package XGBoost. This package deploys quickly and has a lot of power. The boosting strategy is a more efficient and iterative method since it integrates numerous models and predicts the output of the final model, in contrast to decision trees where a single model is trained on the dataset and the outcomes are anticipated. Extreme gradient boosting is used in this study on images of tomato plant leaves so that the newer models can be trained to correct the errors of the older models. Because this approach is an ensemble technique, it works successively with each other and the new model is trained to overcome the errors of the earlier model in such a way that further improvements cannot be made.

### k-nearest neighbors (KNN)

### It is an algorithm that can be used for classification. The idea behind the method is that it assumes that similar things exist nearby. The method takes into consideration the data points of each image in the dataset using Euclidean distance in other to group them. So, when an image is applied to the model, the input image will be converted to a feature vector. Thereafter, the image will be used to construct a color histogram to classifier the color of the pills and then stored under a class label extracted from the image path

###  Disadvantages:

* Features that are manually designed perform well in controlled environments but perform poorly in unrestricted settings, such as with images taken by mobile devices.
* efficient multi-class and binary classification performance on a modestly sized spectrum sample set.
* The disadvantage of using K-Means clustering to segment the image is that the process was only partially automated because the user had to specifically choose the cluster that held the sick portion. SVM - Although the accuracy gained is good, it is insufficient to distinguish between healthy and diseased leaves..

 IV. PROPOSED SOLUTION

Plant disease, that decreases the amount of food provided and the quality of agricultural goods, is a major problem in agriculture. A thorough diagnosis of the disease and treatment protects the plants from catastrophic losses. Image processing has been transformed by convolutional neural networks (CNNs), particularly deep learning methods. Over the past two years, a wide range of potential uses for autonomous crop disease detection have surfaced. Apps for expert consulting or screening can be made using these models.The suggested method offers a method for identifying illnesses on plant leaves using images. Make the case that the method is used to foresee a disease with accuracy. Then, all plant diseases are swiftly discovered. That is used for recognizing all diseases impacting plant leaves and provides greater accuracy.

There are three situations in this ternary model.

1. To determine whether the image of a tomato leaf is correct.

2. One image shows a healthy tomato leaf, and the other is a damaged tomato leaf.

3. Visualization techniques for pinpointing the leaf.

**Region Proposal Network**

The backbone layer-generated convolution feature map that this area proposal network receives as input is transformed into anchors by applying sliding window convolution to the input feature map.



**Gray Level Co-occurrence Matrix**

Kidney disease texture analysis for parametric variations using the Grey Level Co-occurrence Matrix (GLCM). From the pictures used in the experiment, the GLCM parameters Energy, Correlation, Contrast, and uniformity were obtained for each colour component. The coarseness, linear dependency, textural uniformity, and pixel distribution of the texture are each reflected in contrast, correlation, energy, and homogeneity. The GLCM parameters' histograms' analysis revealed that the aforementioned textural aspects are disease-dependent. By using a suitable deep learning algorithm, the method can be used for the accurate identification of CKD ailments.



**Convolutional Neural Network (CNN)**

A deep learning method called CNN assesses visual scenes. Its distinctive characteristics include a fully linked layer that generates the required results and one or more hidden layers that extract characteristics from videos or photos. The image displayed on the computer, in contrast, is a 3D array (width, height, depth) of numerical values that vary from 0 to 255. The image is simply colour pixels if there are only one or zero channels; otherwise, it is grayscale, black, and white. likewise if the images are RGB, there are three color channels. CNN Deep Network displayed exceptional performance in multiple image processing competitions because of its precise outcomes. CNN is an organizational framework with several layers.



**ConvNet Training**

The two primary objectives of training a ConvNet are to boost the variety of the experimental data and prevent over fitting comparable to the training data set. The dropout strategy is used between two fully connected layers to reduce over fitting and avoid complicated co-adaptations on training data [19]. The output of each neuron is predetermined with a chance of 0.5 to be zero.

**Proposed Deep Model**

 The recommended structure is examined using data from the University of Edinburgh and the California Institute of Technology. By reducing candidate detection windows during both training and testing stages, a detector using HOG+CSS and Linear SVM may decrease computation. A total of 60,000 training data that were not clipped by the detector were used to train the deep model. The HOG+CSS+SVM detector, which has screened the bulk of data, only needs just a fraction of our deep model's time to run during testing. The deep learning model has a learning rate of 0.025 and a batch size of 60.

**Fine Tuning Method**

These networks' large feature representation capabilities allow them to do traditional photo categorization with greater accuracy. Despite this, fine-grained categorization only emphasises relatively minor differences across different species. The conventional image recognition network can't be used to accurately categorize fine-grained pictures. A particular approach tries to transfer the network trained on huge amounts of data to an extremely fine classification and recognition challenge. This strategy was prompted by the idea of transfer learning [10]. Typically, weights for networks that have already been trained on ImageNet are used as a starting point, and they are then fine-tuned using information from a dataset of very fine-grained categorizations.

**Part Detection Method**

Humans typically swiftly check an object for any unique characteristics before carefully comparing and understanding those regions. Similar to how humans classify fine-grained images, the target obstruct-based method for identification divides the task into two parts: identifying the location of the area and learning the fine-grained features present in the area. In the graphic, the target is initially located, and only then is the target's region with the prejudiced region discovered. Then, the discriminative target region block and the desired picture (foreground) are simultaneously fed into the deep convolutional network for feature extraction and classification. When putting the discriminative region, convolutional characteristic responses of deep neural network constructions are often employed in a strongly supervised or lightly supervised manner.

**Fine grained future learning Mechanism**

As a way to differentiate between like characteristics in fine-grained categorization, this method often utilises many DCNNS. The output from the two feature extractors in the bilinear model is multiplied and combined at every point in the image using the cross product to produce the image descriptor. The cub200-2011 dataset achieves 84.1% precision in classification without bounding Box annotations using VGG-D and VGG-M networks as reference networks. The architecture can simulate locally paired feature interactions in a translation-invariant manner, which is notably helpful for fine-grained categorization, and the classification accuracy with bounding Box is as high as 85.1%.

**Virtual Learning Mechanism**

Currently, target detection, recognition, and other computer vision tasks all take advantage of the CNN network-based visual attention technique. The focus model can also be applied to deep convolutional networks to find intriguing or distinguishable regions in images. Depending on the task at hand, convolutional networks concentrate on distinct areas of interest. The primary objective of computer vision's mechanism for attention is to train the system to pay attention by ignoring irrelevant information and focusing on important information. The idea is to find correlations using the data that is accessible, then highlight some important qualities. Vision attention model-based computations have lately been widely used for fine-grained image classification because they can recognize distinct areas in images without having to ask for additional annotation data.

**DCGAN – Network building**

GAN is made composed of the discriminator network D and the generator network G, which allows G to learn how the data are distributed. GAN consists of two separate networks, one of which is a generator network called G. This network gets a random noise called z (random number), and it uses this noise to produce images. D is a discriminator network that assesses whether or not a picture is "real." A picture is represented by the input parameter x.

**Pre Training of ANet**

Classifying 8,000 categories with a softmax loss is a straightforward method for training an ANet. To maintain the intra-class invariance, there aren't enough samples of each identity, which makes it difficult. The separations between samples of the same identity are shortened. By combining the softmax loss and the similarity loss, ANet is pre-trained.

 V. PROCEDURE

**Pre-processing**

Green Tomato Preparing images for use in model inference and training processes is known as image pre-processing.

The actions to be taken are as follows: 1. Read image

 Converting RGB to greyscale

 3. Resize image - All of the photographs are reduced in scale to less than 200KB and have a maximum resolution of 1280 by 720, as larger images will take longer to train the algorithms.

 4. Resized image (220, 220, 3) from its initial form (360, 480, 3), (width, height, number of RGB channels)

 5. Reduce the turbulence (Denoise) - We'll smooth down the image to get rid of any extra noise. Gaussian blur is used to accomplish this.

**Bi-lateral Filter**

Perhaps the most fundamental process in computer-based image processing is filtering. In its broadest definition, "filtering" refers to the estimation of the filtered picture at a particular position as a component of the estimations of the initial image in a close proximity to that site. For instance, in Gaussian low-pass filtering, each pixel is replaced by an average weight of its neighbours, with the weights getting smaller the farther they are from the area of focus. Although there are formal and statistical reasons for this weight difference, it makes sense to average them together because close pixels are likely to have comparable values given how gradually images change in space.

Binarization

 Image binarization is the process of taking a grayscale image and turning it into a binary image of black and white. This effectively reduces the amount of information present in the image from 256 shades of grey to 2.

 Split Dataset Training Data

 WPA2 Depending on the requirements of the experiment, only 80% of the input data for training is used to create a CNN model. In order to acquire information from the training data set, it is used to teach the CNN model. The training data contains both the projected outcome and the input.

**Test Data**

 To assess the CNN model on fresh data, a test set of 20% of the original data is employed. Once the model has been fully trained, it is used for evaluation.

**Tomato Leaf Detection**

Take Inception\_5b as an example: through the per-network, a shared feature map with a size of 7 7 256 is created. Region Proposal Networks are an essential component of the detection model. With the use of 3 3 convolution kernels, the feature map is then reshaped to a 7 7 512 format. The 1 1 convolution method is used in the classification layer and regression layer to produce feature maps with sizes of 7 7 30 and 7 7 60, respectively, for categories and regression results. The candidate boxes are obtained at last using the arranged anchors.

A proposed RPN structure for finding the irregular and multiscale sick areas draws inspiration from Feature Pyramid Networks. Inception\_5b's high semantic information and Inception\_ResNet-v2's high resolution are combined using a deconvolution procedure. In order to forecast diseased patches independently in each feature layer, the proposed detection model is presented. The ability of the model to identify tiny sick patches is also improved by the use of top-down up sampling and bottom-up feature extraction.

**Tomato Leaf Feature Extraction**

 Following the detection of leaves, the detected image is fed into the feature extraction module, that distinguishes the crucial features that will be utilised for classification. Each image's facial data, including its shape, size, and pattern, is automatically retrieved before being utilised to figure out the variation's impacts by comparing it to templates for frontal barriers.**GLCM Feature Extraction**

### These statistical texture features are extracted using GLCM (Grey Level Co-occurrence Matrix). While the GLCM determines the exact location of the pixels with respect to their texture, obtaining the histogram details offers no information about the texture. This statistical method provides a great deal of details regarding the relative positions of the adjacent pixels in an image. A spatial domain approach called GLCM tabulates the variations in pixel brightness in a picture. The steps involved in estimating the characteristics are as follows: The grayscale image is used to build the first four co-occurrence matrices. It takes into account that there are 1 pixels between each other. The pair-wise matrix is therefore calculated at 00.

###  Tomato Leaf Disease classification

### A deep learning system called a convolutional neural network gives each entity or objects in an image an assigned score, assisting in learning and identification. Even Convolutional Neural Networks were created using neurons found in the human brain, taking in mind that humans have a visual cortex. The following justifies why these CNNs have been chosen over other neural network topologies. In comparison to other neural networks, convolution neural networks require a lot less pre-processing. CNNs are effective in extracting temporal and spatial information from images. CNN's network can be trained to more fully understand the image's key elements.

### Testing Phase: Prediction

### Following the training procedure, the algorithms were tested on 20 images, including those from the test dataset that featured leaves in various states of health and disease in addition to several other water-based individuals.

### Prediction Network

This detection network's goal is to yield a final bounding box by taking into account inputs from the feature network and local proposal network. It consists of four completely connected layers, each of which is coupled to the classification and bounding box regression layers, which together produce the final detections.

### Keras

### On the basis of the machine learning framework TensorFlow, Keras is a Python-based deep learning API. It was created with the goal of enabling quick experimentation.

### • enables seamless operation of the same code on both CPU and GPU.

### • Convolutional networks (used in computer vision), recurrent neural networks (used in sequence processing), and any combination of both have built-in support.

### • Supports arbitrary network designs, including layer sharing, model sharing, multi-input or multi-output models, etc. As a result, Keras may be used to create virtually any deep learning model, from a memory-based network to a neural Turing machine.

### BACKEND

 We utilised the quick, scalable, and easy to use database management gadgets Mysql as the backend. For the creation of robust and dynamic server-side or web-based applications for businesses, it is utilised in conjunction with PHP scripts. Additionally, we have employed WampServer, which enables us to build web applications that use the Mysql database. In addition, PhpMyAdmin makes it simple to manage our database. We used the Python framework flask, which often has minimal to no need on other libraries.

 VI. SYSTEM IMPLEMENTATION

 Problem Description

 Our approach offers a way to recognize pests and diseases impacting tomato plants using Deep Learning-based technologies. A main analysis unit (Bounding Box Generator), an additional diagnostic unit (CNN filter bank), and an integration unit make up the system's three fundamental building blocks. The primary unit creates a set of bounding boxes with scores for a specific class instance and the coordinates indicating the position of the target for each image and class category. The secondary unit then filters each box's confidence by training separate CNN classifiers for each class to further Perify their example. The integration unit is the last step, where the conclusions from the main and secondary units are merged.

MODULE DESCRIPTION TOMATO LEAF DISEASE PREDICTOR AND RECOMENDER WEB UI:

Python and MySQL are used for developing the Web UI using the Flask Framework. Website Interface We employ a front-end application for analyzing photos that are supplied from sources like an external camera or downloaded from the internet because the entire process of model training and performance is carried out in the backend. As soon as we look at these test images, the results are quickly depicted using the interface and can be simply evaluated with the aid of backend processes.

It offers this system a high level of security. The host will send the challenge message when a server tries to connect to a network resource. User will create hash value for the supplied assignment.

**SYSTEM TESTING**

 Testing occurs to look for errors. Testing is the process of looking for any flaws or weaknesses in a piece of work. It offers a technique to test if parts, subassemblies, assemblies, or a finished product are working. It is the process of testing software to make sure it fulfils user expectations and needs and does not fail in a way that is unacceptable. Tests come in a variety of forms. Every test type answers to a specific testing requirement.

### Test objectives

• Each field entry has to function properly.

• The designated link must be used to activate the pages.

• Delays on the going into screen, messages, or responses are not appropriate.

### Features to be tested

* + - Check that the entries follow the proper format
		- Disallow duplicate entries
		- Ensure that all links direct users to the appropriate page.

### FUNCTIONAL TESTING

### Functional tests deliver rigorous evidence that the functions being tested are available in accordance with the technical and company specifications, system records, and user guides. Functional tests are organised and prepared with a focus on requirements, vital functions, or unique test cases. Additionally, testing must take into account comprehensive examination of business process flows, data fields, established processes, and subsequent processes. Additional tests are found, and the value of the existing tests is evaluated before functional testing is finished.

### Dataset Description

The aim of this project is to determine the kind of plant from an illustration of a leaf, as well as whether it is healthy or plagued by a disease. The dataset is an amalgamation of all the photos from Kaggle, with 1000 images per class for training and 100 images per class for testing. The images span from healthy to multiple tomato leaf diseases, and the training dataset has 10,000 images divided into 10 classes.

 VII. RESULTS AND CONCLUSION

The dataset is put through pre-processing in this, which uses a noise filter and binarization. Following that, segmentation utilizes background extraction and foreground extraction for leaf detection. The feature extraction method, that occurs after segmentation, takes characteristics like edges and texture. The CNN classifier uses the processed, grayscale image to figure out the type of disease that is present in the leaf. Then, for the stage of testing, we provided a total set of 1000 images with 100 for each class offered from the Kaggle website, and for the training phase, we offered a total set of 10,000 images with 1000 for each class.

