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Deep Learning-Based Recognition of Plant Leaf Diseases

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ABSTRACT

Early and accurate disease detection is crucial for effective crop management. This paper proposes a deep learning-based system for automatic plant disease detection using image processing techniques. Our approach leverages Convolutional Neural Networks (CNNs) to analyze images of leaves. The CNN is trained to identify various diseases based on visual symptoms like black and brown spots, mimicking the methods employed by human professionals. This system offers real-time crop monitoring and eliminates the need for farmers to switch between multiple disease control strategies without proper diagnosis. By analyzing image features, the system automatically categorizes the disease present in a captured image. Our research demonstrates that this approach achieves high accuracy in disease detection, potentially leading to improved crop health and yield.

Keywords— Deep learning, Convolutional Neutral Network (CNN),Plant Leaf Diseases Image.

1. INTRODUCTION

India is cultivated country and about 60-70% of the population depends on agriculture. Agriculture provide food to all human beings even if the population is increasing day by day still farmers cultivating the crops to feed the people. Development of the technology in the farming sector and education sector is essential it is far more important to develop this sector to complete increasing need of peoples and students .

In education sector is essential to provide and acquire knowledge to each and every student to grow there knowledge about what type of disease should occur on any plant. These plant leaf recognition system help them to improve their knowledge. Basically agriculture and biotech student got help to identify what type of disease on the leaf and in the research field it might be helps a lot.

Developed technologies have provided the ability to produce sufficient food to meet the demand of society. But still, the safety and security of the food or crops remained unattained. Factors like change in climate, the decline in pollinators, plant disease, and others are challenging to the farmers. However, many illnesses spread by plants have the potential to do significant damage to communities economic and social systems. The disease drastically reduces the plant’s growth and productivity. Determining the full scope of a plant disease has always been challenging. Impressive achievements have been obtain in these field of leaf based image classification.

Our website can be used by farmers and agricultural professionals or students to identify disease early and take appropriate action. On the homepage of the website there is detailed explain about the how to use it. The students just have to capture or upload the leaf image to the website.The diseases will be easily predicated with 96% accuracy.

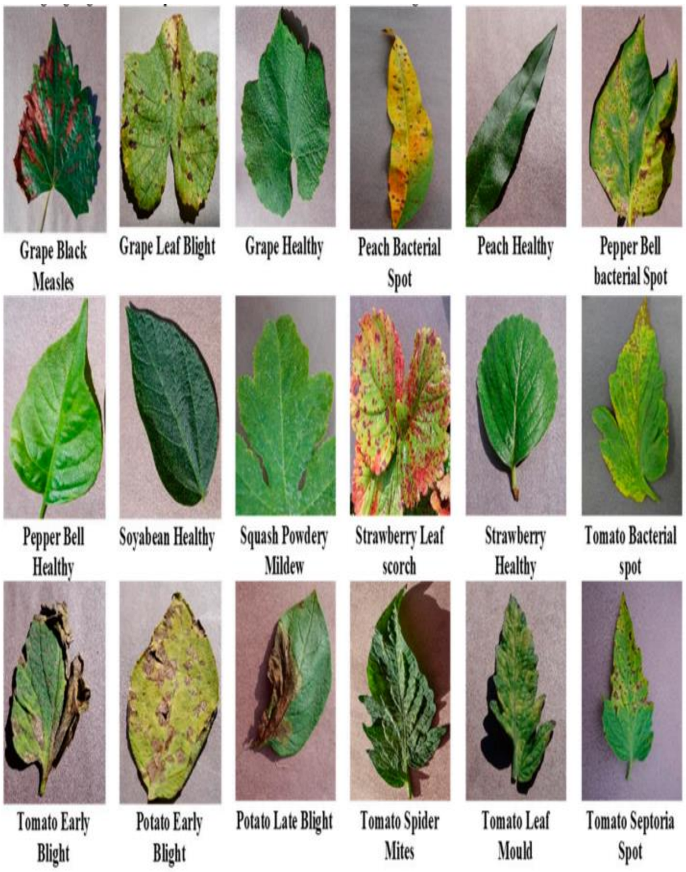

Figure 1:Collection of Healthy and Infected Leaf

2. LITERATURE REVIEW AND OBJECTIVE

Individuals worldwide rely on agriculture industry as one of the most significant businesses since crops are the main source of food. For the farming industry, it is important to recognize specific circumstances early on. The goal of this paper was CNN were utilized to identify and detect 32 distinct types of plants as well as plant diseases. Using trained model, plant illnesses can be recognized and detected in real-time photographs. The current dataset could be expanded to include more plant varieties and plant ailments in order to increase the number of trained models for the upcoming work. [1].

Using the CNN approach, we have created a model in this work that can categorize potato leaf states such as early Blight, late blight, and healthy, with an accuracy of classification of about 97%. The practice of augmenting the data makes the model more reliable. Our method can assist farmers in increasing agricultural yields and identifying diseases early on [2].

There are numerous proven methods for identifying and diagnosing phytopathogens utilizing the leaves of sick plants. But there isn't any expensive, precise commercial technology available for sickness diagnosis. Illnesses that are still not properly acknowledged affect agricultural productivity and can lead to long-term problems like poverty and climate forcing . Observers compared pictures of healthy and diseased leaves as well as the names of the affected plants in our study, Plant Disease Detection System. [3].

In this study, deep learning is introduced and recent deep learning research on plant leaf disease detection is reviewed. The combination of YOLO v7 and GPT-3 presents a viable way to precisely detect and treat leaf diseases. With great recall and precision, YOLO v7 is an excellent tool for identifying and localizing leaf diseases. The integrated system delivers information, automates the detection of diseases, and makes practical suggestions for managing diseases. It could improve farming methods, lower crop losses, and advance sustainable farming approaches[4].

In organic farming, crop protection is a complex issue. It requires in-depth understanding of the crops being farmed as well as the likelihood of pests, diseases, and weeds. Within our framework Based on certain convolutional neural network designs, unique deep learning models were created for the purpose of identifying plant illnesses from photos of healthy and sick plants. Our detector used pictures that were both obtained from different sources and taken on-site by different camera equipment[5].

For the sake of this study, leaf pictures are scaled and cropped to maintain consistent size. To enhance the image quality, the method is applied. Segmentation is accomplished using K-means clustering. The counter tracing method is used to extract the leaf image's boundary. A variety of descriptors, including DWT, PCA, and GLCM, are used to extract relevant information from leaves. Lastly, the collected features are classified using CNN and KNN. The suggested method operates with 86% accuracy[6].

An program designed to identify, manage, and track plant diseases allows farmers to work less hours and do tasks more efficiently. This application increases farm productivity while assisting the farmer in putting in less work. The suggested approach aids in the detection of plant diseases and the observation of various environmental factors. After processing the image in MATLAB, neural network classification was used to determine the leaf's condition[7].

As a result, an application for identifying diseased versus healthy plants has been developed. The suggested work, which is carried out using a variety of plant disease photos, focuses on accuracy values under actual field situations.

In order to improve accuracy, further work will involve expanding the number of photos in the preconfigured database and adjusting the architecture to match the dataset[8].

We have surveyed several plant diseases and the technologies available for their detection in this research. According to the review, machine learning and image processing methods have greater promise for illness detection. As a result, studies on the use of neural networks for plant leaf disease detection have just lately started[9].

3. MATERIALS AND METHODS

CNN techniques and models are used to identify species and illnesses in crop leaves. It contains images of 9 basic diseases, 1 bacterial diseases, 1 diseases caused by infection, 2 viral diseases and 4 disease caused by a fungus. 5 crop species also have healthy leaf images that are not visibly affected by disease. Our dataset contains solutions for several plant textures such as; we are taking for Tomato, Potato, Stewberry, Apple, Soybean, Graphs, Pepper bell.

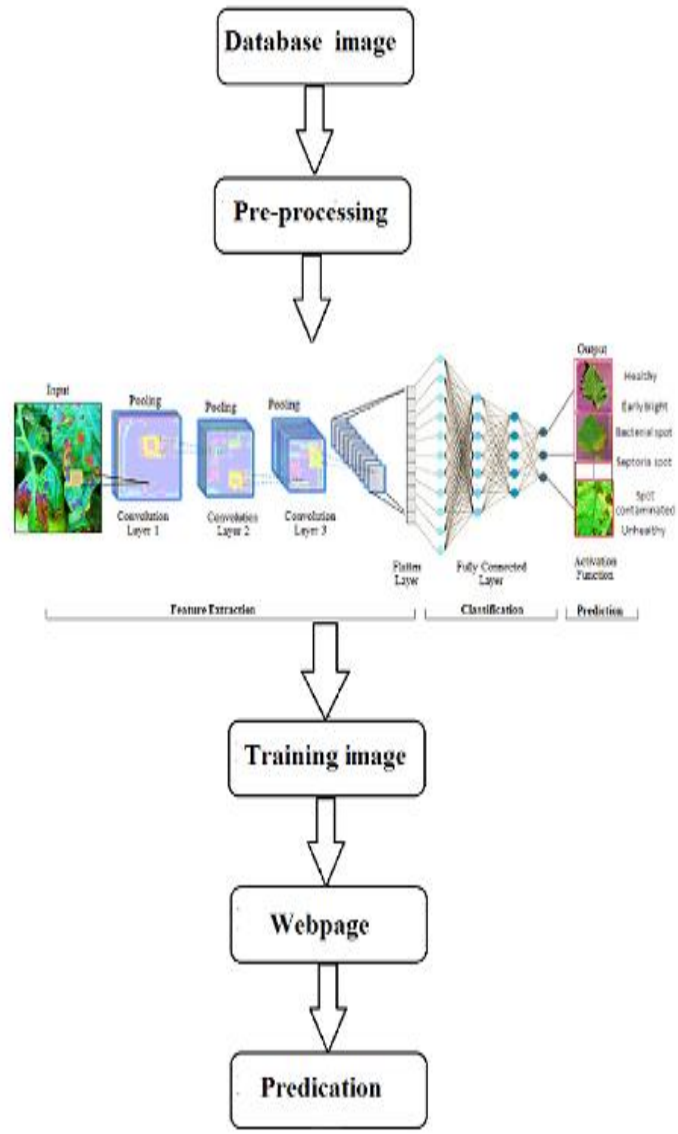

Figure 2: Flow of the system

- **CNN(Convolutional Neural Network)**

CNNs are a type of Deep Neural Networks that are commonly used for visual image analysis. They are capable of identifying and categorizing specific features from images. Applications for them include computer vision, natural language processing, medical image analysis, image and video recognition, and image classification. In general, all use 3 to 4 filters for their program but as we use five filters to increase accuracy in our program to get the best result . To ensure that we are not getting the wrong result.

Their specific types and architecture of hidden layers, namely

- Convolutional layers
- Pooling layers
- Fully connected layer (the final layer)

1.Convolutional Layer

In image classifiers, convolution layers are the main building components. The combination of two functions (f and g) to create a third function (z) is referred to in mathematics as convolution. After applying a filter to an input, the convolutional layer produces a feature map. Convolution layer refers to the combination of input and filter (f and g) in the feature map (z).Convolution's main goal is to extract an image's features. A feature is a particular aspect of the original image, like the dog's nose shape, points, or edges. A feature converts into a box of numerical pixel values, much as the image being processed as numerics.

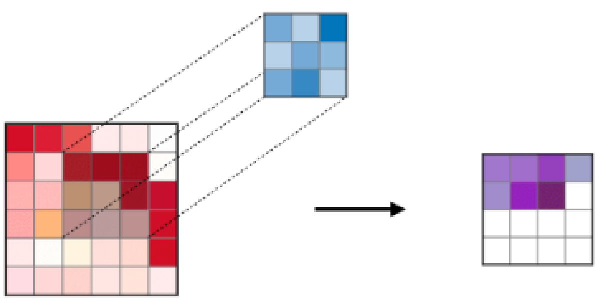

Figure 3: Convolutional Layer

2. Pooling Layer

A filter is applied to the input matrix during the pooling process, designating a single value per sub region to a new output matrix. Reducing the size of an image is the primary goal of pooling. Your image classifier's processing speed will rise as a result. Max pooling is the most used method of pooling.

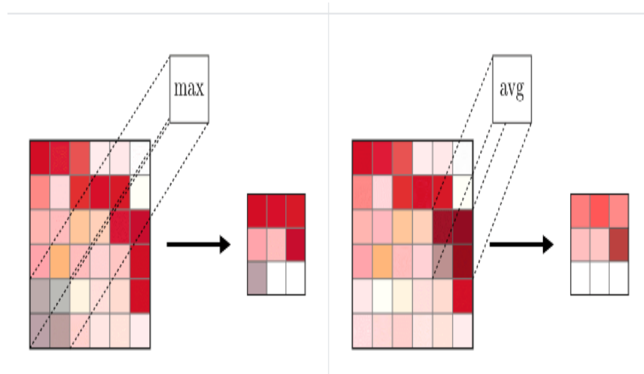

Figure 4: Pooling Layer

3. Fully connected Layer

CNNs complete the fully connected layer. Using the last pooling layer's output as an input, it compiles all the data and produces the final classification. At this point, the likelihood that a feature belongs to a certain class is represented by each value in the input vector. One number, for example, may indicate that there is a 90% chance that the paw belongs to a dog. The nose could be associated with another value. After applying weight to all the data, the fully linked layer produces a final classification.

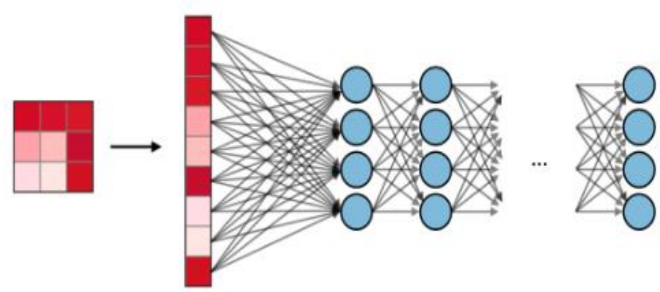

Figure 5: Fully connected Layer

- **Training**

There are various steps in the deep learning training process The training process in deep learning for plant leaf disease recognition involves several steps :

- **Data Acquisition and Preparation:**

1.Dataset Collection: It is required to have a collection of pictures showing both sick and healthy leaves. You can accomplish this by taking your own photos. (https://www.kaggle.com/datasets/emmarex/plantdisease), or by combining the two.

2.Data Labeling: Every picture must be labeled with the appropriate disease class (for example, "healthy," "rust," "blight," or "healthy" if the leaf is devoid of disease. In order for the model to learn the correlation between certain diseases and visual attributes, this labeling step is essential.

3.Preprocessing: To maintain uniformity, images may go through pre-processing. The formats and sizes of images can differ. Pre-processing makes ensuring that every image is converted into a standard format that works with the input layer of the model. Because of this uniformity, the model is not distracted by differences in size or color and can concentrate on learning the underlying qualities pertinent to the task.

This might entail:

3.1.Resizing and rescaling : Standardizing image proportions to ensure compatibility with the input layer of the deep learning model.

Standardization: The width and height of images are frequently not the same. To guarantee that the model handles data with consistent dimensions, resize every image to a standard size. This enhances network compatibility and streamlines computations inside the CNN.

Rescaling: Depending on the image source, pixel values in an image can have different ranges. These values are normalized to a common range (often 0 to 1 or -1 to 1) by rescaling. The model can concentrate on the relative intensity patterns within the image thanks to this normalization, which stops pixels with higher intensity values from controlling the learning process.

3.2.Color normalization: Process of reducing color fluctuations caused by lighting or camera effects that could affect the identification of diseases. The distribution of color values in an image is often determined by illumination, which can change based on a variety of elements such as cameras, lighting, and other variables. Color normalization compensates for these variances by enabling color-based object recognition systems.

Color Normalization: Mitigating Variations: Lighting variations, camera settings, or other factors can introduce color inconsistencies in images. Color normalization techniques aim to reduce these inconsistencies and make the color information more consistent across the dataset.

Focus on Content: By reducing unwanted color variations, color normalization helps the model focus on the actual content of the image rather than being influenced by lighting or camera effects. This is particularly important in medical image analysis where subtle color variations might hold significant diagnostic information.

- **Model Construction and Instruction:**

1.Model Selection: For image recognition applications such as illness diagnosis, convolutional neural networks (CNNs) are usually used. The size of the dataset and the available computing power can be taken into consideration while selecting the particular CNN architecture (e.g., VGG16, ResNet).

2.Model Definition: The deep learning framework defines the selected CNN architecture.

3.Loss Function and Optimizer: The difference between the true labels and the predictions made by the model is measured using a loss function, such as categorical cross-entropy. During training, an optimizer (like Adam) is used to iteratively modify the internal parameters of the model in order to minimize the loss function.

4.Training loop: The central component of the procedure. The model receives batches of training data. For every group:

- For each picture in the batch, the model forecasts the illness classes.
- The difference between these predictions and the true labels is computed using the loss function.
- With each iteration (epoch), the optimizer employs the loss value to modify the internal parameters of the model, increasing the accuracy of the predictions.

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- **Model Evaluation:**

1.Training set : A training set is a group of samples used to train a model in deep learning. Following training, the model's ability to generalize to new cases is assessed using a testing set of data—ideally, never-before-seen data.
Hidden Data: The code doesn't make the training set itself explicitly visible. It's probably a different dataset with pictures and descriptions in it.Learning Source: The training set is essential to deep learning and comes before the assessment you see (cnn.evaluate(training set)). During the training phase, the CNN model receives this dataset.Model Development: The model analyzes training set instances several times as it is being trained. The model modifies its internal parameters as it processes each image-label combination in order to identify the patterns that distinguish distinct image categories. In essence, this aids the model's "learning" process of matching an image with its appropriate label.

```
#Training set Accuracy
train_loss, train_acc = cnn.evaluate(training_set)
print('Training accuracy:', train_acc)
```

```
11/11 [==============================] - 6s 555ms/step - loss: 0.0102 - accuracy: 0.9970
Training accuracy: 0.9969512224197388
```

2.Validation Set: It's possible to save some training data as a validation set. Throughout training, this set is utilized sporadically to keep an eye on the model's performance and guard against overfitting. When a model performs poorly on unseen data and memorizes the training data too well, it is said to be overfitting.

```
#Validation set Accuracy
val_loss, val_acc = cnn.evaluate(validation_set)
print('Validation accuracy:', val_acc)
```

```
11/11 [==============================] - 6s 550ms/step - loss: 0.0102 - accuracy: 0.9970
Validation accuracv: 0.9969512224197388
```

3.Testing Set : Following training, a final assessment is conducted on a different testing set that was not used throughout training. This set offers an objective evaluation of the model's applicability to actual data.

4.Evaluation Metrics: To assess how well the model performs in diagnosing various diseases, metrics including as accuracy, precision, recall, and F1-score are computed.

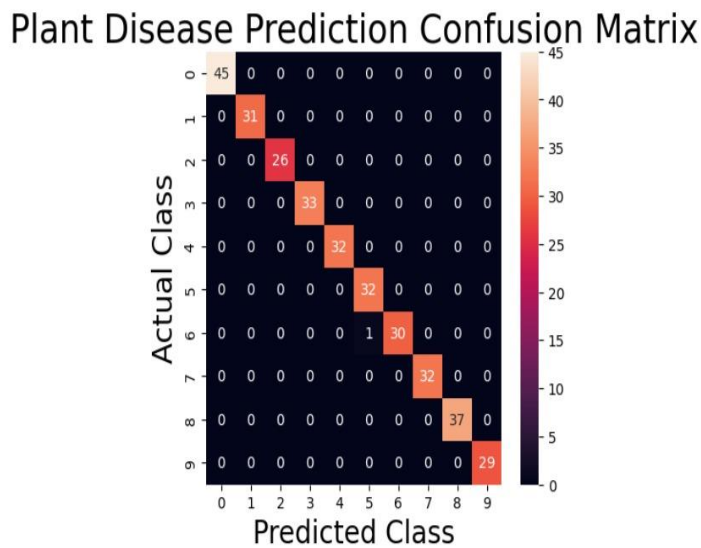

Figure 6: Plant Disease Confusion Matrix

4. RESULTS AND DISCUSSION

This section presents the results of training using the entire database, which includes both original and augmented photos. Results obtained from training convolutional networks with only original images will not be examined because it is well known that these networks can acquire new features when trained on larger datasets. Following network parameter optimization, an overall accuracy of 96.67% was attained. Moreover, every class was tested separately using the learned model. All of the images in the validation set were tested. A comparison between the acquired results and other results is recommended by the principles of good practice. Furthermore, aside from commercial systems that identify plant species from photographs of their leaves, there are currently none on the market. This study investigated the use of deep learning techniques to automatically identify and categorize plant diseases using leaf photos. The entire method was explained in detail, starting with gathering the training and validation photos, continuing with

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image pre-processing and augmentation, and concluding with the deep CNN training and fine-tuning process. Various experiments were run to evaluate the newly developed model's performance. There has never been a comparison of the presented method's findings with similar ones utilizing the same precise procedure because, as far as we are aware, it has not been used in the field of plant disease recognition.

Our Perdication : Tomato___Bacterial_spot (1)

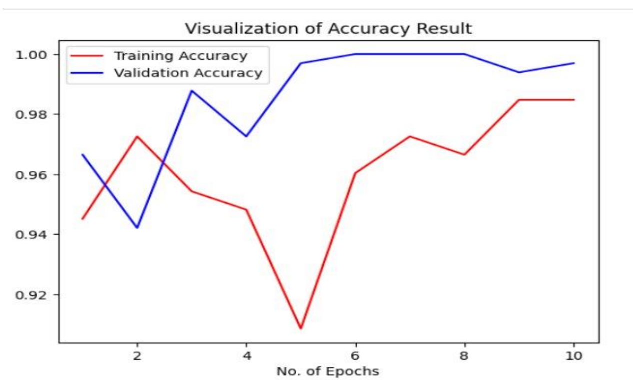

Figure 7: Visualization of Accuracy Result

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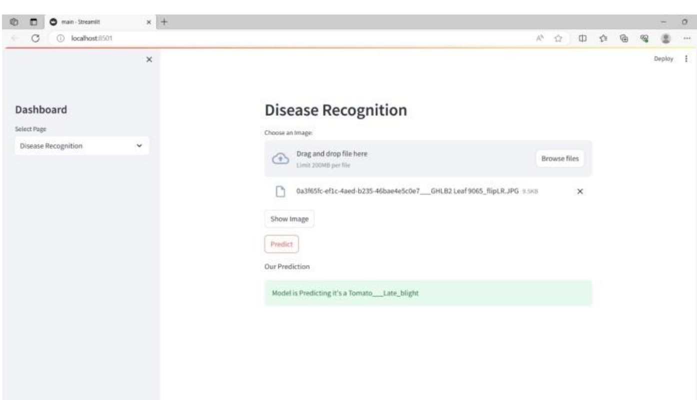

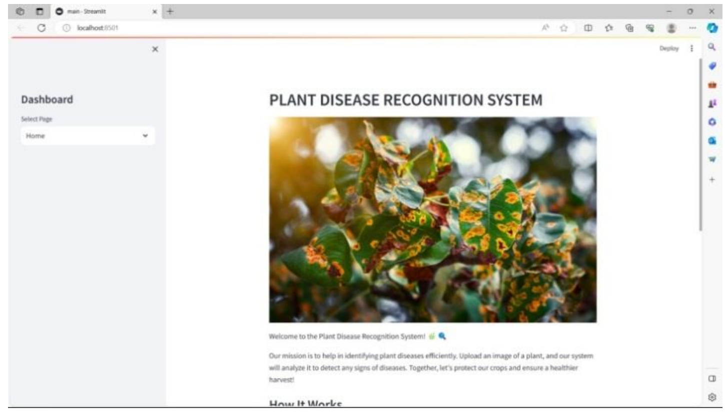

Figure 8: Web page

5. CONCLUSIONS

This study investigated how deep learning might be used to identify and forecast illnesses in plant leaves. In this study, we have developed a model that, with a classification accuracy of almost 99%, can distinguish between various leaf states, such as early blight, late blight, and healthy, using the CNN approach. The model becomes more dependable through the process of data augmentation. Our approach can help farmers detect infections early on and boost agricultural productivity.

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