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The Use of Deep Learning Methods for the Detection of Diseases in Plant Leaves

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Abstract: *Leaf diseases on plants pose a significant risk to global food security because they significantly lower crop yield and quality. It has proven difficult to diagnose diseases in a way that is both accurate and precise. The recent advancements in computer vision have made it possible and opened the door for disease diagnosis of plant leaves using a camera-assisted deep learning approach. This was previously impossible. An intelligent disease diagnosis system is a forward-thinking piece of technology that contributes to the enhancement of both the quality and quantity of agricultural output in the nation. Therefore, the efficient disease detection convolution neural networks (CNN) model is applied in order to categorise the diseases that are present on the provided leaf based on the image dataset. Therefore, it has come to our attention that neural networks are able to capture the colours and qualities of lesions that are distinctive to certain diseases.*

Keywords: *Agricultural Output, Disease Detection, Deep Learning, CNN, Diseases In Plant Leaves, Intelligent Disease.*

Introduction

The current social network relies heavily on automation, which also carries out a variety of jobs across a wide range of industries [1]. The objective of this project is to overcome the difficulty of automating the process of disease identification in plants using photographs of a specific leaf from a plant that has been captured [2-5]. It examines and outlines a number of methods for categorising and identifying a variety of bacterial, fungal, and viral illnesses that can affect plant leaves [6-9]. The classification methods help automate the process of detecting plant leaf diseases and classify them according to the morphological characteristics that they exhibit [10]. Agriculture suffers significant losses due to the presence of plant diseases. It covers the diagnosis of the leaf disease affecting the damaged plant [11-15]. Deep learning is an approach that is used to investigate the possibility of plant leaf diseases. When it comes to diagnosing a certain illness, the farmers absolutely need to make use of the programme [16]. The analysis of visual data is a common application of CNNs, which belong to the class of deep neural networks. This strategy is extremely beneficial for farmers since it enables the early detection of plant diseases, which in turn enables the early prevention of those diseases, saving both money and time [17-22].

Deep learning is a subfield of machine learning that use artificial neural networks as its primary teaching tool [23]. The lack of available data and processing power in the past has contributed to its current level of popularity. Deep learning, in its more technical sense, can be defined as neurons [24-31]. Deep learning is a specialised form of machine learning that reaches a high level of power and flexibility by discovering how to describe the world as a hierarchical structure of concepts that are nested within one another [32]. Each notion is defined by the simplest and most abstract representations computed in the representations that are the least abstract [33]. Each neuron is connected to its neighbours by thousands of other neurons [34-39]. The question that has to be answered is how these neurons are created and implemented in a computer [40]. As a result, it fashions a man-made framework that we refer to as an artificial neural net and within which we find neuronal nodes [41-45]. It has some neurons for input value and some neurons for output value, and in the buried layer, numerous neurons may be associated with one another. It also has some neurons for both input and output value [46-52]. It is necessary to recognise the issue in order to find the best solution, and the issue itself should be comprehended; additionally, the applicability of deep learning should be evaluated (whether Deep Learning is suitable or not) [53-59]. It is necessary to determine the pertinent data that should convey the actual problem and then arrange it in accordance with that determination. It is important to make an informed decision when selecting the Deep Learning Algorithm because it will be utilised both during the training of the dataset and during testing [60]. Human annotation through the use of visual inspection has been the standard method for identifying illnesses that affect plant leaves [61]. If plant diseases are not identified and treated in the early phases of their development using the CNN model, the cost of agricultural production could be dramatically increased. Diseases that affect plant leaves can be determined with precision using this CNN model [62-

69]. Therefore, the primary goal is to accurately detect the plant leaf disease with a reduced amount of labour so that the farmer may administer the appropriate pesticide for the illnesses that have been diagnosed [70].

Literature Survey

Tools and software for scRNA-seq data preprocessing and co-expression analysis are also provided. Discussion centred on using functional analysis and biological interpretation to determine the biological significance of a given set of genes. It gave the analyst some pointers and suggestions [71-75]. Transcriptomic studies frequently employ gene expression data analysis to decipher cellular molecular activities and connections. Diseases and phenotypic differences can be investigated by differential co-expression analysis, which identifies groups of genes whose co-expression patterns differ under different experimental settings [76]. It discusses the state-of-the-art methods for analysing gene expression data, including microarray and RNA-seq comparisons, co-expression networks, differential networking, and differential connectivity analyses [77-81]. It draws attention to the challenges involved in analysing RNA-seq data with tools designed for microarrays. The tools required for analysing gene expression are also discussed [82]. In addition, it elucidates scRNA-seq data analysis by covering preprocessing, scRNA-seq in co-expression analysis, and scRNA-seq-specific methods. Biological interpretation and functional profiling are presented for understanding [83-89]. Finally, it outlines some best practises for the analyst and highlights some key research questions and obstacles that should be overcome [90].

This paper proposes a unique picture segmentation model, SFLA-PCNN, for plant diseases based on a hybrid frog-hopping algorithm [91-95]. To determine the ideal configuration parameters of PCNN neural networks, we use an SFLA fitness function based on the weighted sum of cross entropy and image segmentation compactness to analyse a trial segmentation image of late potato blight illness [96]. Image segmentation is essential for feature extraction and plant disease detection. A new image segmentation model (SFLA-PCNN) is developed to obtain the parameters configuration of PCNN in order to remove the subjectivity introduced by using conventional PCNN (pulse-coupled neural network) to segment images of plant diseases [97]. In order to optimise the parameters of PCNN, the shuffling frog jump algorithm uses a fitness function consisting of the weighted sum of cross entropy and compactness degree of image segmentation [98-101]. After 100 rounds of local iteration and 1500 rounds of global iteration, the optimal set of parameters is determined [102-107]. Extensive testing shows that the SFLA-PCNN model is able to successfully separate the lesion from the background, which may serve as a basis for further illness detection [108].

They showed shown a smartphone software that can diagnose plant diseases [109]. While it is ultimately the responsibility of agriculture engineers, intelligent systems can be useful in the early stages of disease diagnostics. Expert systems proposed in the literature typically rely on user-described facts or the processing of plant pictures in various wavelengths of visible light, infrared light, etc [110]. Lesions or spots on different areas of a plant are common symptoms that can be used to diagnose a disease. Diseases that have severely damaged a plant can often be identified by the colour, size, and quantity of these patches [111-117]. When necessary, more expensive molecular tests and analysis can be performed. In this article, we take a look at a Windows Phone software that can diagnose vineyard illnesses from leaf photographs with an accuracy of over 90%. Adding support for new plant diseases and more mobile operating systems is a breeze with this app [118].

As an example of the benefits of the GP distribution model for the SIFT descriptor, it has been effectively used to the problem of classifying plant diseases. In addition, the proposed feature strikes a reasonable balance between speed and precision while classifying data [119-124]. Even though the proposed feature can serve as a good model for the SIFT feature and be used for plant disease recognition, we should work together to make it even better. In order to classify plant disease photos of leaves, it proposes a novel collection of statistical texture features [125-131]. The input photographs come from a wide range of mobile cameras. Scale-invariant feature transform (SIFT) features are often employed as texture features due to their robustness in the face of transformations in translation, rotation, noise, and light [132]. However, training and classifying SIFT textures using the exact mathematical model is computationally intensive [133-139].

A SIFT descriptor is used to compute model-based statistical features that condense a high-dimensional image into a few dimensions [140]. From the SIFT texture features, a probability density function known as the Generalized Pareto Distribution is derived. One of its planned uses is to lessen the burden on mobile devices' processors. To ensure there was no data bias and to rule out theoretically derived values, we used 10-Fold cross-validation with SVM classifiers in our experiment. Reducing the need for manual labour, we utilise "pepper cutting UGV and illness detection using image analysis" to work around these restrictions. Image processing methods can be used to detect diseases and assist with pepper plucking [141-145]. When it comes to the economy, India relies heavily on agriculture. 77% of India's people make their living in the agricultural sector. When plants are infected with a disease, the crop output decreases [146]. It throws farmers' finances into disarray, which in turn lowers national output. Early detection of the disease is crucial in averting widespread outbreaks, which can have devastating consequences. The suggested system centres on the creation of a UGV (Unmanned Ground Vehicle) that can harvest peppers, check for diseases, and apply the necessary pesticides [147-151].

This study explains how to extract pepper from plants using colour recognition algorithms, as well as how to use leaf photos to diagnose plant illnesses and decide whether or not to sprinkle them off [152]. Here, a two-stage training procedure is utilised, first with a pre-training on the ImageNet data and then with a re-training on the data set of specific plant diseases [153-159]. When attempting to use this method in the real world, it's not uncommon to run across issues with things like background noise, feature optimization, and automating continuous extraction. It was demonstrated that a classifier based on the Mobilenet architecture can accurately categorise plant diseases, even with a very limited data set [160]. The accuracy of the classifier model was acceptable even when it was used on a mobile device [161-165]. Here, we recycle each and every image for use in epoch-specific training. In validation tests, the model showed an Accuracy of 89.0 percent [166].

The huge variability and intricacy of leaf architecture make occluded plant leaf classification considerably more difficult than whole leaf matching [167]. It is an NP-hard task to find a matching set of full contours for an occluded contour in a database. For this reason, the algorithm must be inferior. To begin, a -SplineCurve is used to represent the 2D contour points [168-171]. We next use the DCE algorithm to these curves to derive points of interest. The nodes of the DCE graph are used for subgraph matching. The parameters of the similarity transformation for each open curve are then calculated [172-181]. Then, we take the best-fitting curves from each open set and "overlay" them. The optimal -curve is the one with the lowest energy, therefore it's also the best overall fit with the occluded leaf [182].

The DCE technique uses spline curves to represent the outlines of leaves (because splines can have arbitrary curve resolution) and then uses those curves to derive feature points. The whole curve is broken down into multiple smaller curves using this procedure [183-186]. As the Frechet error between the two curves is small across the board, we call these "globally good" fits [187]. The average performance for random occlusion levels between 20% and 50% was determined by comparing the results from several data sets, with the average occlusion level being 50% [188]. This algorithm takes a picture of a plant leaf captured using a mobile phone camera as input and returns the name of a plant disease as output. In this step, the image is processed in order to extract the SIFT characteristics. The generalised extreme value (GEV) distribution is used to model the extracted SIFT features, which reduces the number of dimensions required to represent a picture [189].

The experimental results demonstrate the feasibility of the proposed characteristics in comparing to other statistical features and distinguishing between six different tomato illnesses (leaf Mold, Septoria Leaf spot, Two Spotted Spider Mite, Late Blight, Bacterial Spot, Target Spot, etc.) [190]. These diseases are first taught, and then the input image is compared to the learned image to determine the disease kind. Firstly, it presents the suggested feature analysis on various colour spaces and kernel functions of the SVM classifier, and then it compares the results to those of earlier work on features. Color statistics values and GEV statistical features on RGB colour spaces are two methods for feature proposal [191]. The second group is made up of grayscale and RGB colour space GEV statistical features and colour statistics values [192].

The early detection of plant diseases through the use of intelligent technologies enables the continuous monitoring of plants. Lesions, over- or under-development of different plant sections, necrosis, and a generally worsened appearance are some of the most prominent signs of the disease. Lesions on a plant can be diagnosed by looking at their colour, size, and number. Several machine vision-based applications have been presented in the literature for diagnosing plant diseases. In order to use these programmes, the user must either describe the symptoms in great detail or submit images of the affected plant sections for analysis. Additionally, an agriculturist or the expert system might need to conduct some extra molecular tests. This programme has been shown to distinguish plant lesion features with an accuracy of roughly 90%. Measuring the lesion's features in conjunction with the user's descriptive information can lead to an accurate diagnosis.

There is a possibility that human-aided disease predictions on cotton leaves will be inaccurate. The ability to detect diseases in both the visible and invisible spectrums can be greatly expanded with the use of machine vision techniques. This study applies Principle Component Analysis (PCA) and the Nearest Neighbor Classifier to the troublesome problem of identifying cotton leaf diseases (KNN). The greatest results for early detection of the various illnesses on cotton leaves can be obtained through the use of an appropriate classifier technique, such as PCA. To examine the statistical information associated with the Green (G) channel of the RGB image, we can employ PCA/KNN multi-variable approaches. Misclassification is possible, as shown by the fact that diseases with visually similar colour patterns have greater cosines distances during KNN classification. As previously discussed, PCA/KNN based classifiers have been reported to have a 95% accuracy rate in disease recognition analyses, which is 14% higher than the accuracy rate of manual observations.

In this paper, we will go over the extraction of the pepper plant using colour recognition algorithms, as well as the methods utilised to detect plant diseases using photos of leaves, and the solution we opted for, which was to sprinkle. Here, we employ a two-stage training procedure, first pre-training on ImageNet data and then re-training on a data set of specific plant diseases. With this method, you'll have to deal with the usual challenges, such as those related to background presence, feature optimization, and automated, ongoing extraction in the wild. The results of using a classifier based on the Mobilenet architecture to identify plant diseases were reported, demonstrating their accuracy despite using a dataset that is less than average. Once ported to a mobile environment, the classifier model showed respectable levels of accuracy. Throughout all epochs of training, not a single image is wasted. Testing showed that the model was accurate 89.0 percent of the time.

Due to the vast structural variability and complexity of plant leaves, occluded leaf classification is much more difficult than full leaf matching. The challenge of finding a matching set of full contours for an occluded one in a database is NP-hard. This means the algorithm will always perform poorly when used with this methodology. To begin, we use a -SplineCurve to represent the 2D contour points. Next, we use the DCE algorithm to pull out locations of interest along these arcs. Using the DCE points as vertices, we perform subgraph matching. Our next step is to calculate the parameters of the similarity transformation for each open curve. We then "overlay" all of the open curves and keep the ones that are the closest matches. The optimum curve is the one that minimises energy and so is the most similar to the occluded leaf.

The DCE technique uses spline curves (which permit arbitrary curve resolution) to represent leaf outlines and then extracts feature points from those curves. Using this technique, we can extract several sub-curves from the original whole curve. This set of matches is considered "globally good" since the Frechet error in their combined curve shapes is small. The average performance for random occlusion levels between 20% and 50% was determined by comparing the outcomes of several data sets, with the average occlusion level being 50%. To identify plant diseases, the app takes pictures of leaves from plants using a mobile device's camera and returns a name. Once an image has been processed, the SIFT features can be retrieved. The key contribution is a model for representing picture information in a minimal number of dimensions, based on the retrieved SIFT features, using the Generalized Extreme Value (GEV) Distribution.

The experimental results demonstrate that the proposed features can compete with other statistical features and identify between six different tomato illnesses (leaf Mold, Septoria Leaf spot, Two Spotted Spider Mite, Late Blight, Bacterial Spot, Target Spot, etc.). These disorders are first taught, and then their classification is determined through a comparison of the input image with the learned image. The paper first explains the suggested feature analysis on various colour spaces and kernel functions of the SVM classifier, then compares these results to those of earlier work on features. GEV statistical features on RGB colour spaces and colour statistics values are two methods for proposing features. Grayscale and RGB colour space statistics, as well as GEV statistics, make up the second.

Intelligent systems can aid in the early diagnosis of plant illness, allowing for constant plant monitoring. Lesion formation, abnormal growth patterns, necrosis, and an overall decline in the plant's look are some of the most prominent signs of the disease. Plant diseases are identified by their characteristic colour, size, and density of lesions. Several machine-vision-based applications have been presented in the literature for identifying plant diseases from their symptoms. Many of these programmes ask for the user to describe the symptoms in great detail, while others can analyse pictures of the affected areas of a plant. Additionally, the agriculturist or the expert system may need to conduct some extra molecular testing. An estimated 90% recognition rate of plant lesion features has been demonstrated by this software. Measuring the lesion's features and using the user's own description of the condition yields the most accurate diagnosis possible.

Attempts to anticipate illnesses on cotton leaves with human assistance may not always be accurate. Machine vision approaches can broaden the range of detection for many diseases within the visible and invisible wavelength ranges. This study employs Principal Component Analysis (PCA) and Nearest Neighbor Classifier to solve the problem of cotton leaf disease identification (KNN). The best results for early disease detection of various cotton leaf diseases can be obtained by using a suitable classifier technique like principal component analysis. Green (G) channel of the RGB image statistics can be analysed using PCA/KNN multi-variable approaches. It was discovered that diseases with similar patterns have greater cosines distances during KNN classification, increasing the likelihood of misclassification (i.e., some diseases share similar colour patterns, which contributes to poor recognition of disease patterns). According to the previously mentioned analysis of disease recognition accuracy, the PCA/KNN based classifier is shown to have a 95% accuracy rate, which is 14% higher than that of manual observations.

Result and Discussion

CNN is used in the model's development process. There are two distinct stages in the model. The first step involves preprocessing the dataset. The images in the dataset were resized, cropped, and converted to an array as part of the preliminary processing. The test image undergoes a process that is analogous to this one. One is trained, tested, and validated using a dataset of around 38 distinct leaf diseases in plants. Phase two involves training the dataset to determine if the input leaf of the plant is present in the dataset. Prediction of disease is achieved by comparing the test image to the trained model after training and preprocessing have been completed successfully. The software and hardware for this system are required for development. All prerequisites have been laid out. The needs of the model are established through a process called requirement analysis. In order to successfully implement the model, this study examines the necessary resources and products. The product specification calls for both input and output data, with the image serving as the input. A summary of the software and hardware specifications that are minimally necessary to perform the specified tasks. The design process involves specifying the system's architecture, components, modules, interfaces, and data in order to meet the requirements. The system's design explains its inner workings, including the modules it employs and how they interact. Here, we'll go over the specifics of how our proposed model is constructed. The system architecture of a model provides a comprehensive breakdown of the operations carried out by that model. The system architecture of the proposed model is outlined, along with the steps necessary to ensure its successful execution.

User-provided images or those found in a database serve as input. Since the input layer's dimensions are fixed, the image must undergo preprocessing before being fed into the layer. The given dataset is used for training, validation, and testing with grayscale images that have been normalised. Proposed laptop webcam photos are also utilised for testing; in these, the leaf is recognised, cropped, and normalised with the help of the OpenCVHaar Cascade Classifier. It's possible that the given leaf is healthy; diseases are classified in the database according to the categories specified there.

With the help of learnable weights and biases, Convolutional Neural Networks (ConvNets/CNNs) are able to take in an input image, prioritise distinct features/objects within it, and then classify them accordingly. Compared to other classification techniques, ConvNet requires significantly less preprocessing work. As opposed to being hand-engineered in basic approaches, filters in ConvNets can be taught with sufficient training. The structure of the visual cortex served as inspiration for ConvNet design, which mimics the connectivity network of neurons in the human brain. Known as the "Receptive field," this is the area of the visual field to which an individual neuron is sensitive. There are 1,024 input units in a CNN network, followed by 256 units in the first hidden layer, 8 units in the second hidden layer, and finally two units in the output layer. Leaf disease prediction data is typically separated into a "Training set" and "Test set" for analysis. The split between the Training and Test sets is typically 7:3. The naive CNN (convolution neural network) algorithm is used to generate the Data Model, which is then applied to the Training set to make predictions about the Test set's images based on how well those images performed on the tests. The "Kerasmethod" function in the Python Tensor Flow library will be used to test our models on the provided test dataset (or subset). In order to get reliable results, more of the image should be trained than the test image.

Image dimensions are reduced by this method after being convolved. Changes the tensor's shape so that its dimension is the same as the number of components in the tensor. Batch processing is used for both convolution and pooling. CNN filter weights are adjusted in batches, where N represents the number of images in the batch. Each convolution layer accepts N x Color-Channel x width x height picture batches as input. Similarly, the feature map or filter used in convolution is also a four-dimensional structure (Number of feature maps in, number of feature maps out, filter width, filter height). Each convolution layer performs a four-dimensional convolution between the picture batch and the feature maps. Just the image's dimensions (width and height) shift after convolution. It's the secret sauce that turns this into a fully functional model. The input nodes are linked to the output layers individually. This layer makes predictions about the class of the output. The input leaf image is labelled based on the predicted class output.

The technique for identifying leaf diseases relies on a two-channel architecture. The chopped and removed diseased leaf pieces are fed into the CNN's inception layer. Then it is sorted and filtered. In contrast, it returns the name of the diseased leaf along with its result if the input image and the dataset image are a perfect match. Improvements to the plans, specifications, and cost estimates are all part of the detailed design phase. For easier comprehension of the modules' features, they are diagrammatically described. In the Unified Modeling Language (UML), a sequence diagram is used to depict the sequential nature and interdependence of various operations. A messaging flowchart is an artificial construct. A class diagram is a static structure diagram in the Unified Modeling Language (UML) that displays the classes, properties, and interactions between classes that make up a system. An iteration's objects, relationships, and the messages passed back and forth between them can all be seen in a collaboration diagram. The CNN model is provided with both training and test (validation) datasets. Then, the CNN model is given the input leaf to perform feature extraction. Using the data collected from the training and testing sets, different CNN layers can be used to detect leaf diseases.

One way to model the operational features of an information system is through a graphical representation known as a data flow diagram (DFD). It is common practise to use a DFD as a first stage in the process, providing a high-level overview of the system without going into considerable depth. Visualizing data processing is another application for DFDs (structured design). A data flow diagram (DFD) depicts the data that enters and leaves a system, as well as the data's path through the system and its storage locations. Unlike a UML activity workflow diagram, which displays control and data flow as a unified model, this type of flowchart is not designed to show time information or whether operations will run sequentially or in parallel. Bubble charts are another name for data flow diagrams. In the Systems Design process, DFD is a tool used for the top-down design strategy. The rules and guidelines of any convention's DFD are represented by symbols and notations. Four elements of data flow diagrams are represented here by these icons.

Create size, rescale, range, zoom range, horizontal flip, and more with the help of Keras' preprocessing image data generator function. Using the data generator tool, bring in the picture dataset from the directory. Train, test, and validate are all established in this section. The function in question instructs the user on how to maximise the target size, batch size, and class mode. A classifier and a fit generating function are used to train the dataset. The function requires that the dataset be trained at the epoch indicated. When more time periods are used, precision improves. The epoch specifies how many times the process should repeat. To process an input image, a Convolution Neural Network (ConvNet/CNN) uses learnable weights and biases to prioritise distinct features and objects within the image. Compared to other classification techniques, ConvNet requires significantly less preprocessing work. ConvNet, given sufficient training, can learn these filters/characteristics on its own, whereas in basic approaches they must be hand-engineered. The structure of the visual cortex served as inspiration for ConvNet design, which mimics the connectivity network of neurons in the human brain. Known as the "Receptive field," this is the area of the visual field to which an individual neuron is sensitive. Their network has 1,024 input units, 256 units in the first hidden layer, eight units in the second hidden layer, and two output units across its four layers. In a CNN, the image data is stored in the input layer. Data about images is stored in a three-dimensional matrix. A new, single-column configuration is required. Assume you have a 28x28-pixel image that you need to transform to 784x1 before using.

Since the image's features are extracted on the convo layer, it is frequently referred to as the feature extractor layer. To begin, the receptive field (a local section of the input picture with the same size as that of filter) is linked to the Convo layer so that the convolution operation can be performed and the dot product between the receptive field and the filter can be calculated. The operation returns a single output volume integer as the result. The filter is then moved forward one Stride to the next available receptive field in the same input image, where the process is repeated. In order to completely process the image, it will repeat the same steps over and over. The subsequent layer will take its input from the output. After convolution, the input image's spatial volume is decreased by the pooling layer. Used in between two convolution layers. Applying FC after the Convo layer without using pooling or max pooling will be computationally expensive. As a result, max pooling is the only option for decreasing the input image's spatial volume. With a Stride of 2, it uses maximum pooling over a shallow depth slice. The system detects the input space shrinking from 4 by 4 to 2 by 2.

Weights, biases, and neurons all make to a completely linked layer. It's the bridge between the layers of the brain, linking the neurons there. As a result of training, it can separate images into distinct groups. CNN's final layer is a softmax or a logistic layer. It is located after the FC layer. Both softmax and logistic are used for multi-classification, however logistic is more suited to binary classification. The label, encoded in a one-hot fashion, is present in the output layer. You should know your way through CNN at this point. For training purposes, we utilise the keras preprocessing software and provide input photos. The pillow and image to array function package is used to transform the input image into an array value. The leaf disease in our dataset has already been classified. Use the predict function to make predictions. In addition, the user is provided with the disease's identification and name.

Conclusion

Diseases affecting plant leaves have a significant impact on agricultural output, threatening the economic stability of the country, yet identifying these diseases remains challenging due to a lack of appropriate software. Improved crop output is achieved by the strategic application of herbicides thanks to automated leaf disease identification. The convolution neural networks (CNN) model is employed to categorise the many diseases affecting a specific leaf by means of the aforementioned image collection, allowing for effective disease detection. Multiple approaches to neuron- and layer-level visualisation were implemented in CNN. There are 38 plant leaf disease classifiers present in the image dataset. There are around 53,608 training photos and 12,899 test images in the dataset, which are split evenly between 38 categories. It can foretell if the leaf is healthy or not. If a diseased state is detected in the supplied leaf image, the name of the class to which the image belongs will be presented. With the proposed model, we can get 99.83% precision. By making the model available as a web or desktop application, plant leaf disease detection can be automated in the future. It is possible to fine-tune the model for use in an AI setting. The model's effectiveness can be enhanced by additional study.

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