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Plant Disease Classification of Basil and Mint Leaves using Convolutional Neural Networks

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Abstract: The main hub for the Indian economy is agriculture, which shares a great part of the gross domestic product, and nearly 70% of the people rely on it. Identification of proper medicinal plants that go into medicine formation is essential in the medicinal sector. Plant disease identification plays an essential part in taking the control measures for disease and developing the quantity and quality of the crop yield. The automatic disease identification in plants from their leaves is one of the most challenging tasks for researchers. The diseases among plants degrade their performance and result in a huge decrease in agricultural products. Plant disease automation is very much advantageous as it decreases the supervision work in big farms. The leaves being the plant's food source, the accurate and early detection of leaf disease is essential. This study proposes a convolutional neural network approach that automates the identification of Basil and Mint leaf diseases. The advancement in CNN has changed the way of image processing compared to traditional techniques of image processing. This study has used the Inception V3 model for classification and to identify the types of diseases that occurred in Basil and Mint plants. The model was compiled using Adam Optimizer. The results of the study generated a validation accuracy of 77.55% for Basil leaves and an accuracy of 70.89% for mint leaves

Keywords: *basil leaves, convolutional neural networks, Herbal plant leaf disease detection, mint leaves*

1. Introduction

Plants have become an essential energy source and play an essential part in handling several environmental problems. Many diseases affect plants of importance leading to devastating social, ecological and economical losses. There are many ways to predict diseases in plants. Some diseases cannot be identified with naked eyes, and some show up only when it is too late to perform upon them (Kaur et al (2016; Singh and Misra, 2017). Poonkuntran et al (2018) have mentioned that the leaf's external appearance denotes the plant's healthiness. Ancient medicines were dependant mainly on herbal plants (Subramani and Subramaniam, 2020). Plants have been utilized for medicinal needs long before the pre-historic time. In the ancient period, India was known for the rich repository of its herbal plants. The major source of raw material from the herbal plant is the leaves, hence recognizing whether the leaves are fresh and healthy is very essential.Loolaie et al (2017) have mentioned that medicinal plants have acquired much attention because of their health advantages, such as anti-infectious properties since ancient times. Medicinal plants are known for natural remedies that have been used for human disease treatment. Medicinal plants are regarded as a valuable ingredient source that can be used in the development of medicines. Medicinal plants have essential importance for human societies and consumed by people across the whole world. Nearly 80 percent of the population in the world use medicinal plants and traditional medicine for their primary needs of health. Mint is a perennial aromatic medicine belonging to the family of Lamiaceae, which is a natural hybrid between water mint and spearmint. Mint is cultivated all around the world for its use in fragrance, flavour and also used in pharmaceutical applications Khalil et al, (2015). Authors Kalamartzis et al., (2020), Topolovec-Pintaric and Martinko (2020) studied the diseases in Basil; and the authors, El-Mougy et al (2007), Dung (2020) studied the diseases in Mint. According to their observation, the diseases through fungal and bacterial infections in plants, i.e. infected leaves (wilting, curling, spotting, etc), infected stems and roots, could be observed and classified under human intervention.

Vijayashree and Gopal (2018) have mentioned that recognizing the medicinal leaves among the lookalike leaves is the major task of all. As of now, to recognize the herbal leaf qualities, an automated identification system has been incorporated. A user-friendly method is used for the advantages of farmers, for the purpose of agriculture, and also for normal humans who are not aware of herbal medicines. The automated identification system involves

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techniques of image processing for creating herbal leaves database by retrieving features based on the parameters of shape, texture and also involves parameters of colour to classify within different kinds of Ocimumtenuiflorum (Tulsi). Hemalatha et al (2015) have mentioned in their study that Basil is a reversed homegrown traditional plant with huge cultivation and history in India. The basil commercial success as a culinary herb is obvious from its vast spread use in different familiar cuisines. Its rapid developing habit and suitability for various conditions of climate have enhanced its big scale cultivation globally. Singletary (2018) has stated that Basil is an aromatic plant that involves scores of herb species and shrub species belonging to the genus Ocimum L. (Lamiaceae). The main uses of Basil species involve stress relief, treatment of gastrointestinal, respiratory and kidney ailments, as well as, disorders of the blood, eye and skin diseases.

Dhingra et al (2019) have mentioned that the conventional approach of determination and classification of the disease in herbal leaves is manual. However, this manual method is tedious, subjective, and time consuming. Several methods were evolved using computer vision to classify and detect horticultural and agricultural crop diseases to resolve the manual techniques issues. The general method for all these approaches involves feature extraction, image acquisition, classification and feature selection analysis with non-parametric or parametric statistics. The choice of image processing approaches and classification strategies are of major concern for efficient performance of computer vision system (Dhingra et al, 2018). Mainkar et al (2015) have mentioned that there are two major features of plant disease detection ML methods that must be accomplished, they are accuracy and speed. There is a requirement for developing techniques, such as automatic plant disease classification and detection using the techniques of leaf image processing. This may assure helpful technique for farmers and also warn them at appropriate time before spreading the disease over huge area (Sasi et al, 2018). Tripathi and Save (2015) have mentioned that identifying the diseases in plants in a timely and accurate way is of huge significance. Among many approaches to predict pathologies of plants, the machine learning based recognition and detection method has the importance to recognize, and therefore, handle the diseases in its earlier stage. The diseased leaves images can be examined using the technique of computer image processing, and disease spot features can be retrieved according to their texture, colour, and other features. The image processing techniques has been used in plants to predict the specific disease for precision agriculture (Pujari et al, 2015).

Kambale and Bilgi (2017) have mentioned that computer plays an essential part to evolve the automatic approaches for the classification and detection of diseases in leaves. There can be different image processing and pattern recognition techniques that can be employed in the detection of leaf diseases. The classification and detection of leaf diseases is the key to hinder the loss in agriculture. Automatic plant disease detection is an essential task that proves advantageous in supervising a huge number of crops and thus, automatically predicts diseases from symptoms that occur on the leaves of plants. Thus, automatic plant disease detection with the use of image processing techniques offers much guidance for the management of disease (Shamkuwar et al, 2018). Hang et al (2019) have mentioned that with the rapid growth of computer technology, the traditional methods of machine learning have been used in the prediction of plant diseases much widely. With the familiarity of algorithms of machine learning in computer vision, in order to develop the speed and accuracy of diagnostic outcomes, the automated diagnosis of plant disease based on traditional machine learning algorithms have been studied.

Sharma et al (2016) have mentioned that the artificial neural network is considered as an effective technique for detection of leaf disease in plants effectively. An artificial neural network is a mathematical or computational model that is inspired by the functional and/or structural perspectives of biological neural networks. A neural network comprises of an interlinked set of artificial neurons, and it processes data using a connectionist method to computation. In several cases, the artificial neural network is an adaptive system that alters its structure based on internal or external data that flows through the network during the phase of learning (Suman and Deshpande, 2017). Muthukannan et al (2015) have developed an NN algorithm for the diseased classification of plant leaves. The neural network technologies, namely learning vector quantization, radial basis function network, and feed-forward neural network, were verified for two varied leaf diseased image classification, such as bitter gourd and bean leaves. The performance is estimated using the parameters of classification such as precision, accuracy, f-measure and recall ratio. The performance is examined with these four parameters, and based on the examination the feed-forward neural network classification method offers good outputs (Ranjan et al, 2015). The study examines and classifies the Mint and Basil (herbs) leaves diseases using machine learning model, where Inception V3 is a new novel concept with CNN. Though there are similar studies combining two herbs to find the diseases with multi-class classification was attempted in this study as the novelty. Thus, it can be inferred that neural network proves to be an effective method for detection and classification of plant diseases.

2. Literature Review

Ananthi et al (2014) have mentioned in their study that medicinal leaves have been used widely in the medicine, cosmetic and pharmaceutic sector. Knowing about the herbal leaves are essential in the futures. Nevertheless, the present way of determination and identification of the type of herbal leaves is still performed manually and prone to human error. The species of leaves is important since it develops herbal species efficiency of classification. In this study the identification method recognizes the texture and shape features of herbal leaves. In this study, first, some features are retrieved from input leave image later using various approaches like segmentation and thresholding. After image pre-processing, the data are used to neural network and compared with many trained databases. This study examines the herbal leaves with a successful image processing.

In the study of Fulsoundar et al (2014), medicinal plants were used much in herbals to study the plants' medicinal properties. The NIRS (Near Infrared Spectroscopy) applications have extended vastly in the field of plants, agriculture, and different other fields, but the use for plant variety identification is rare still. In this study, an Android application is developed that provides users with the capability to recognize the species of plant based on pictures of plant leaves taken with a smartphone. At the heart of this application is an algorithm that needs morphological characteristics of leaves, evaluates well-documented metrics, namely ACH (angle code histogram) then categorizes the species based on novel integration of evaluated metrics. The algorithm is trained first, against many known plant species plants, and then utilized to categorize unknown species of a query. Supported by designed features into the application such as rotation of touch screen image and preview of contour, the algorithm is very successful in identifying species properly comprised in the library of training.

Khan and Pandhare (2015) have stated in their research that plants play an essential part in the environment and in human beings' lives from an economical and medicinal viewpoint. To offer the management and understanding of plants in medicine, botany, food sector, and industry, the recognition systems of leaves can be employed. By identifying leaf flowery plants and trees can be classified easily. This study explains the recognition of a leaf, which enhances users to identify the leaf type using a method that relies on a neural network. Scanned images are being established into computer initially, reduction of noise and image enhancement changes their quality further followed by extraction of the feature. The feature selection from the geometric mid of the leaf image and compares them with trained feature points of database leaf image is the basis for the recognition system of a leaf

Sekeroglu and Inan (2015) proposed a study on the leaf recognition system using an artificial neural network. The identification of the plant is an essential sector of medical and biological sciences. Medicinal plants must be recognized and classified with greater accuracy. The errors of classification can lead to greater losses and costs. The classification is carried out manually, and it is based on human classifier experience. In this case, the process of classification is restricted by the knowledge and experience of human experts. On the other side, using the speed and accuracy of computer technique can be useful in creating a greater performance classification system of plant-based on the recognition of leaf. This study proposes an automatic identification process of a plant using an ANN that can identify plants' leaf images. Various plant images are collected and are processed as input to the artificial neural network. The results showed the greater effectiveness of ANN for identification of leaf.

According to the study of Ishak (2015), nowadays, herbal plants are essential to the medical sector and can give an advantage to human beings. In this study, PhyllanthusElegans Wall is used to classify and examine whether it is an unhealthy or a healthy leaf. This plant was selected because its function can cure breast cancer, rather than utilize the technology namely surgery, chemotherapy or the medicine used from the hospital. The main aim of the study is to recognize the leaf quality and using a technique in the field of agriculture. The leaf disease image analysis is applied based on shape and colour. The method of classification uses feed- forward NN which utilizes the algorithm of back-propagation. The outcome shows the comparison between Radial Basis Function and Multilayer Perceptron, and Comparison between RBF and MLP showed in an accurate percentage.

Sladojevic et al (2016), propose a new method for the growth of plant disease recognition model based on the classification of leaf image by the use of deep convolutional neural networks. The recent generation of convolutional neural networks has accomplished better outcomes in the image classification field. The novel way of methodology and training enhance an easy and rapid implementation of the system in practice. The developed model is capable to identify various kinds of plant diseases out of healthy leaves with the capability to differentiate the leaves of the plant from their environment.

Selvakumari and Manohari (2016) have mentioned in their study that techniques of shape modelling include leaf structure identification and classifying them according to their structure. The model of moment invariant handles with transition, scaling and rotation of images for the identification process. This study proposes two methods to predict the disease classification and scientific name of leaves which can lead to the leaf being researched further.

A neural network is framed to implement this cause, further developing the classification process. This classification can be employed in the medical field to recognize rare species of medicinal plants. An artificial neural network, also known as a neural network, is a computation and mathematical model based on biological neural networks. It is used for the classification of abnormal and normal leaves.

In the study of Venkataraman and Mangayarkarasi (2016), plants are regarded as one of the biggest properties in the Indian Science of Ayurveda and Medicine sector. Certain plants have their values of medicine apart from serving as a food source. The allopathic medicine innovation has degraded the importance of therapeutic plants. People failed to have their medications at their doorstep and instead went behind rapid cure, unaware of its side effects. One of the reasons is the lack of knowledge about recognizing medicinal plants among usual ones. So, a vision-based method is used to create an automated system which recognizes the plants, and offers their medicinal values, thus supporting a common man to be aware of medicinal plants around them. This study explains the feature set formation, which is an essential step in identifying any species of plant.

The study of De-Luna et al (2018) comprises a system that includes the techniques of image processing to retrieve similar characteristics associated with leaf in conjunction with using ANN to identify and detect certain herbal plants of the Philippines. Many characteristics are retrieved using image processing techniques. With the ANN performing as an autonomous network of the brain, the system can recognize the herbal medicinal plant leaves species being verified. The system also offers data about the diseases which herbal plants can cure. The experimental outcome shows 99% accuracy in the identification of the herbal plant.

Keskar and Maktedar (2019) have mentioned in their study that recognition of the right herbal plants that move into the medicine formation is essential in the ayurvedic medicinal sector. This study focuses on the automatic recognition of therapeutic plants that are used regularly in Ayurveda. The major factor needed to differentiate herbal plants is their leaf colour, texture and shape. This study proposed an EAC-AMP (efficient accurate classifier for ayurvedic medicinal plant) identification using hybrid optimal machine learning techniques. The corners of the image are detected first in EAC-AMP then the bottom and top edges of the leaf are evaluated by the improved edge detection algorithm. Then the segmentation is accomplished using a spider optimization neural network after pre-processing which segments the regions of leaf from an image. Lastly, a whole optimization with Deep Neural Network classifier is employed to characterize the plant type. The main aim of the EAC-AMP method is to increase the classifier accuracy.

The Table 1 shows the reviews of algorithm used to detect herbal plant disease using neural network:

Table 1. Reviews of algorithm used to detect herbal plant disease using neural network

Source: Author

S.No.	Author	Year	Technique or Algorithm Used	Benefits of the algorithm or Technique
1	Ananthi et al	2014	Neural Network	Used to find the disease in medicinal leaves easily and conveniently.
2	Fulsoundar et al	2014	BP Neural Network	Classifies various types of plant leaves.
3	Khan and Pandhare	2015	Feature Point Extraction and Artificial Neural Network	Identifies the correct leaf of a plant effectively.
4	Keseroglu and Inan	2015	Artificial Neural Network	Capability to provide greater efficiency and categorizes the leaves set, based on the concentration of colour.
5	Ishak	2015	Artificial Neural Network	Classifies healthy and unhealthy leaves using ANN.

6	Sladojevic et al	2016	Deep Convolutional Neural Network	Differentiates the healthy leaves and diseased leaves clearly from the environment.
7	Selvakumari and ManohariA	2016	Artificial Neural Network	Classifies the abnormal and normal leaves. separately
8	Venkataraman and Mangayarkarasi	2018	Probabilistic Neural Network	Takes lesser amount of time to train the data and it is known for its time complexity.
9	De-Luna et al	2018	Artificial Neural Network	Identifies the herbal medicinal plant leaves species which is being tested.
10	Keskar and Maktedar	2019	Image Edge Detection, Spider Optimization Neural Network and Deep Neural Network	SONN is used for process of segmentation, and DNN is used to characterize the plant type with greater accuracy and efficiency.

3. Proposed System

This study proposed a plant disease identification system for herbal plants using a neural network. The image data of Basil (Ocimum) and Mint leaves are collected for this study. The algorithm based on neural networks would be designed. The proposed algorithm was tested on the following diseases, namely Fusarium Wilt, Rust and Powdery mildew. This study builds two classifiers using a convolutional neural network for predicting the following classes: 1) the basil classifier classes are classified into healthy basil, unhealthy basil (wilted) and unhealthy Basil (Mild dew); and 2) the mint classifier classes are classified using the healthy leaf of mint, mint leaf rust, fusarium wilt mint leaf and powdery mildew mint leaf. The proposed flow diagram used in the identification of plant disease in Basil andMint leaves is shown in Fig.1.

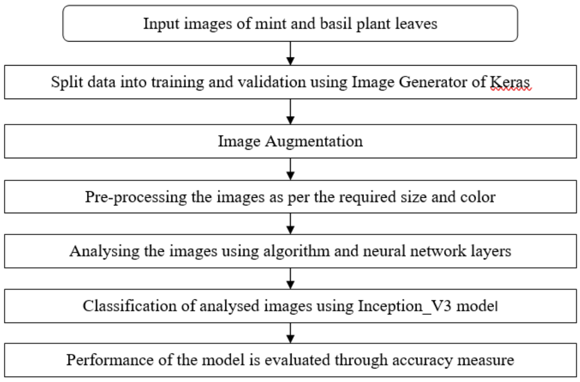

Fig.1. Proposed Flow Diagram

Source: Author

3.1 Image Acquisition

In image processing, this is the first step, and the Basil and Mint leaves are considered as input for further processing. For further examination, easy analysis and proper visibility of leaf images and white background are created because the colour of several leaves differs from red to green for accurate segmentation. This study has considered the most popular image domains so that any image format can be considered like .bmp, .gif, and .jpg as input to the process. The real-time images are captured from the camera directly.

3.2 Splitting Data into training and validation using Image Generator of Kera

Keras exists with several useful functions of utility and classes to achieve all types of tasks in pipelines of machine learning. One evenly used class is the Image Data Generator. The Image Data Generator generates tensor image data batches with real-time augmentation of data, and the data is looped over in batches. The Image Data Generator is helpful in the classification of the image. There are many ways to utilize this generator, relying on the method used. The Image data generator is a simple way to augment and load images in batches for tasks of image classification. The Image Data Generator class of Keras works by: 1) accepting image batches employed for training; 2) using this batch, a set of random transformation is applied to every image in the batch; 3) replace the actual batch with the new transformed batch randomly; and 4) convolutional neural network training on transformed batch randomly. The Image Data Generator approves the original data, transforms it randomly and returns newly transformed data only. Presently the validation and training sets of data are put together by creating two separate structures of a folder for their images to be used in conjunction with the function of flow from a directory. A new parameter of validation_split was added to the Image Data Generator that permits to split a subset of the training data randomly into a validation set by denoting the percentage needed to allocate to the set of validation. Then the flow_from_directory is invoked where the subset parameter is passed, denoting which set they need. Both generators are being loaded from TRAIN_DIR, where the only difference is that one uses the subset of training and the other uses the subset of validation. Though Keras offers data generators, they are restricted in their abilities. One of the reasons is that each task requires a varied loader of data. Sometimes each image has one mask, and sometimes many, and sometimes the mask is saved as an image and sometimes it is encoded. The advantages of using the Image Data Generator is simple to write, simple to integrate, less to remember and rapid.

3.3 Image augmentation

Data augmentation includes a vast number of techniques employed to generate new samples of training from the original ones by using perturbations and random jitters. The main purpose when using augmentation of data is to enhance the model generalizability. The augmentation of data is a strategy that is used to increase the data amount by using techniques like padding, cropping, flipping, etc. The augmentation of data makes the model much robust to slight differences and hence hinders the model from overfitting. It is neither efficient nor practical to store augmented information in memory, and that is where the class of Image Data Generator from Keras exists. Image Data Generator generates tensor image data batches with real-time augmentation of data. The output images produced by the generator must have similar dimensions of output as the input images.

Since the set of data is not too large to denote for different image variations, this study used various augmentations. The augmentations used for this study are width shift, height shift, range of brightness from 0.3 to 1.0, vertical flip, horizontal flip and range of rotation from 0 to 300 degrees. The range of width shift is a floating-point number between 0 to 1, which indicates the upper bound of the fraction of the whole width by which the image is to be shifted randomly either towards the right or left. The height shifting is similar to width shifting, where the image is vertically shifted instead of shifting horizontally. The range of brightness indicates the range for picking a shift value of brightness randomly. The brightness of 0.3 indicates minimum brightness absolutely, and 1 indicates maximum brightness. After brightness, the image data generator is applied with vertical flip instead of applying horizontal flip. In horizontal flip, the generator produces images on a random basis which is flipped horizontally. By indicating the range of rotation, the generated data is rotated randomly by an angle in the range of positive range of rotation to a negative range of rotation.

3.4 Image pre-processing

As the images are obtained, they may comprise spores, water sots and dust as noise. The main aim of data pre-processing is to remove the noise in an image so as to adjust the values of pixels. It develops the image quality followed by smoothing and clipping of the image. The enhancement of the image is undertaken to enhance the contrast of the image. The RGB images are transformed into grey images using the conversion of colour by the formula:

$$F\,(n) = 0.3 * R + 0.58 * B + 0.11 * B \tag{1}$$

Then the equalization of the histogram is used in which the image intensity is distributed using the function of cumulative distribution. Image processing comprises two steps, namely the conversion of colour space and normalization of the image. The captured image has been transformed into a normalized image in image normalization. Then the normalized image colour space has been transformed into a grayscale image. There are 3 steps involved in the phase of pre-processing, namely smoothing, enhancement and clipping. Noises that may be acquired from the image collection process and a huge amount of data which may be led easily from the operation and saving to the image would make the image quality reduced, thereby affects the disease. So, the low-quality image must be smoothed by a filter. Various types of noises occur in an image, and a different number of noise reduction methods is feasible to perform de-noising. The median filter performs well with the noise of salt and pepper by selecting the proper threshold. A median filter is a nonlinear filter, and it is used to predict the value of median across the window, changing every window entry with the median pixel value. It is best in eliminating the impulse and salt and pepper noise. The image dataset of Basil and Mint leaves comprises both unhealthy and healthy leaves. All are colour images having 3 channels that are Red, Green and Blue. The Table 2.shows the dataset for leaf disease image classification:

Table 2. Dataset for Leaf Disease Image Classification

Class	No. of Original Images	Total No. of Images: Augmented and Original	No. of Images from used dataset for validation
(1) Healthy Basil	550	4500	320
(2) Unhealthy Basil (Mildew)	245	2120	158
(3) Unhealthy Basil (Wilted)	100	1280	80
(4) Healthy Mint Leaf	148	1510	150
(5) Fusarium Wilt Mint Leaf	220	2340	200
(6) Mint Leaf Rust	115	1420	110
(7) Powdery Mildew Mint Leaf	250	2050	185
	1628	15220	1203

In the step of pre-processing this study performs real-time augmentation of data where the images are generated with different geometrical changes such as vertical flip, horizontal flip, range of rotation, rotation range, width shift, height shift, and range of brightness. In this study, the images are pre-processed using the inception V3 pre-process function to make it applicable to the model.

3.5 Classification Using Inception_V3 model

In this study, various models were tried, and the best performing model i.e. inception_v3, was used for the classification of both cases. The model was trained from scratch with 2 fully connected layers in the end. The inception module is the major tool of the GoogLeNet network. The structure of inception involves multi-scale data, and collects features from various receptive fields to develop the performance of identification. It manages the sparse structure, enhances the depth, and expands the network width; therefore, it decreases not only overfitting but also free parameters. The inception module utilizes three varied kernels of convolution, namely 1 * 1 convolution, 3 * 3 convolution, 5 * 5 convolution as well as 3 * 3 max-pooling layer. It retrieves three varied features of scale to raise features diversity including, both microscopic and macroscopic features. The pooling layer purpose is to secure the primitive input data. The module splices the retrieved features in dimension channel and results in a multi-scale feature map by combining the pooling and convolutional layers together. The architecture of Inception-V3 model is shown in Fig.2.

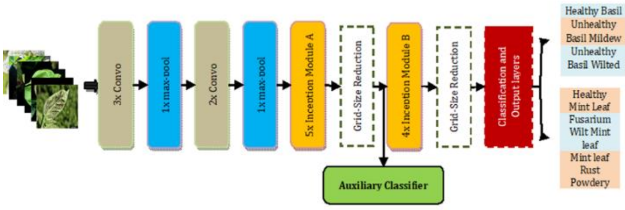

Fig. 2: Architecture of Inception_V3 model

Source: Author

The architecture of inception deep convolution was established as GoogleNet in Szegedy et al (2015b) by extra ideas of factorization in the third iteration, which is known as Inception_V3. The purpose of factorizing convolution is to decrease the set of parameters/connections without reducing the efficiency of the network. The auxiliary classifiers were recommended in Inception-v1/GoogleNet. There are certain changes in the model of Inception V3. Only one classifier is used on the top of the last 17 * 17 layer instead of using two auxiliary classifiers. The auxiliary classifier is employed as a regularizer in the Inception_V3 model. The auxiliary classifiers did not support much near the training process end when accuracies were moving to saturation. The auxiliary classifier performs as regularizes specifically if they have operations of drop out. The downsizing of the feature map is performed by max-pooling conventionally. But the challenge is either too greedy by the layer of max pooling followed by a convolutional layer or too costly by convolutional layer followed by a max-pooling layer. An effective and less expensive network is accomplished by the effective reduction of grid size. The softmax classifier is used as a loss function. The function of SoftMax is the soft version of the max function. Instead of choosing one value of the maximum, it breaks then whole with maximal element getting the biggest part of the distribution but other little elements getting some it as well. This SoftMax function property results as probability distribution which makes it applicable for probabilistic interpretation in tasks of classification.

3.6 Validation Accuracy

In this study, convolutional neural networks are used in the detection of plant leaf diseases. A Convolutional neural network is selected as a tool for classification due to its well familiar technique as a successful classifier for several real-life applications. The validation and training methods are among the essential steps in evolving an accurate model process using convolutional neural networks. The set of data for validation and training methods comprises of two sets, namely the set of training feature, which is utilized to train the model of the convolutional neural network, while a testing set of features is used to verify the training convolutional neural network model accuracy. The model was compiled using Adam optimizer. The Adam optimizer was used to train the convolutional neural network weights based on small batches of 32 size. The Adam optimizer was used with varied rates of learning. The model was trained till the validation accuracy of 77.55% was obtained in basil and accuracy of 70.89% was achieved in mint

4. Discussion and Results

4.1 Discussion

This study trained the CNN network using the loss function. Neural networks are often trained using gradient descent, and it needs to select training loss function when designing the model. There are several loss functions to select from, and it can be challenging to know what to select or even what a loss function is and the role it plays when a neural network is trained. Neural networks are always trained using the process of optimization that requires a loss function to estimate the model error. The loss function is associated directly with the activation function used in the output layer of the convolutional neural network.

4.2 Results

The results obtained from the proposed study are depicted below:

4.2.1 Input Images

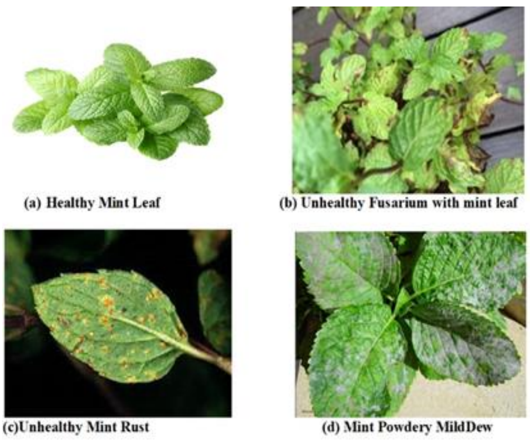

Fig. 3. Dataset of Input images

4.2.2 Classification results

(a) Mint leaf rust (b) Fusarium wilt mint leaf

Fig. 4. Results of Predicted classes

4.2.3 Training Loss

The Fig.5.shows the training loss function graph. The x axis represents the number of epochs and the y axis represents intervals.

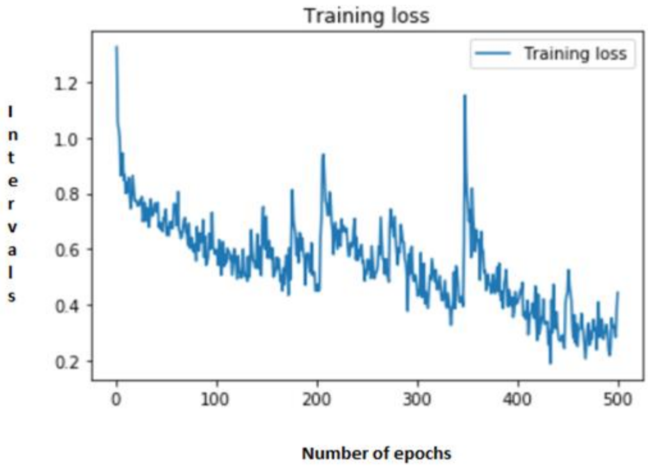

Fig. 5. Training loss

Source: Author

Inference

It can be inferred from the above figure, that the training loss was greater at zero intervals and the training loss was reduced gradually at 500 intervals

4.2.4 Accuracy

Fig.6.shows the accuracy graph: The x axis represents the number of epochs and the y axis represents the accuracy.

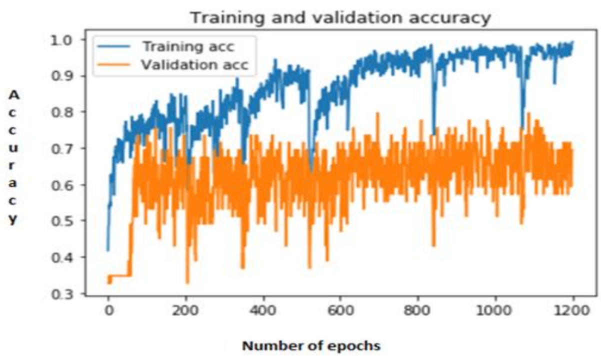

Fig. 6. Training and Validation Accuracy

Source: Author

Inference

From the above figure 6 it can be inferred that the blue line indicates the training accuracy, whereas the orange line indicates the validation accuracy. The validation accuracy for Basil obtained was 77.55% and for mint obtained was 70.89%.

4.2.5Comparative analysis

There are studies that focused upon herbal plants as study materials under the machine learning models. However the lack of basil and mint under one focus had never been attempted in Indian context. Thus, in this research, basil along with mint has been studied to identify and classify the diseases with 7 classifications using the Inception-V3. The similar studies with mint and basil as focuses are listed in Table 3.

Table3. Plant diseases identification and classification models

S. No	Author	Year	Plant diseases	Neural Network and Classification	Accuracy
1	Dhingra et al.,	2019	Basil plant diseases identification and classification	CNN Two-classes: Basil: healthy and unhealthy	95.73 %
2	Sladojevic et al.,	2016	Mint plant diseases identification and classification	DNN Two-classes: Mint: healthy and unhealthy	96.3%
3	Proposed CNN model	2022	Basil and Mint plant diseases identification and classification	CNN with Inception-V3 Multi-classes: a) Basil: healthy basil, unhealthy basil (wilted) and unhealthy Basil (Mild dew); and b) Mint: healthy leaf of mint, mint leaf rust, fusarium wilt mint leaf and powdery mildew mint leaf.	78% = Basil 71% = Mint
4	Zhao et al.,	2020	Herb plant leaves: diseases identification and classification	CNN+VGG 16 Multi-class: Random herb plants: healthy and unhealthy	87%

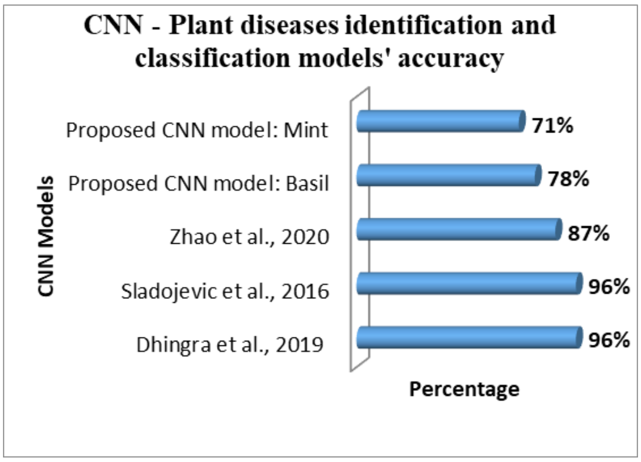

Fig. 7. Plant diseases identification and classification mdoels Interpretation

From Fig.7.it could be observed that, the models with highest accuracies (96%) has trained and used minimal classification where the herb plant as input is just single class (mint or Basil). Similarly in the multi-class with more than 2species of herb plants the model attained 87% as accuracy but with classification as healthy and unhealthy. In the developed research the classification is further classified (sub-classes) into 7 classifications and thus the accuracy is presumed as a good outcome. In the near-future the same model is aimed to be improvised with hybrid algorithms to heighten the accuracy (i.e. 90-95%) and attain a more accurate and precise model.

5. Conclusion

Early identification of disease can hinder huge loss for farmers and thus the productivity increases and thereby the economy also increases. Since many diseases are predicted to be affecting leaves but they are less serious in nature and their occurrence probability is also less so the main stress in this research was on the diseases affecting leaves. This study has proposed a convolutional neural network method to classify the Basil and mint leaves with diseases. CNN approach has been used for efficient recognition of the disease in leaf images of diseased or healthy plants. The methodology has been used in the leaves of Basil and mint plants. An average accuracy has been registered using the Inception V3 model. The images required for the experiment is taken from different places by a camera and also collected from different sources. The results of the study obtain a validation accuracy of 77.55% was obtained in basil and an accuracy of 70.89% was achieved in mint. In future this methodology can be applied to several numbers of diseases successfully that can span to a huge number of plant species.

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