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# Using AI to Recommend Pesticides for Effective Management of Multiple Plant Diseases

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## Abstract

*Trees, Plants and Crops are one of the principal sources of food for humans as well as other animals. They are crucial for our continuance. Similar to us they are also living organisms. Once in a while we get afflicted by diverse diseases. Like us, plants are also affected by various types of illness. Plants that are infected by disease have results on their health which have severe consequences like less food production. Most plant ailments are contagious which spread rapidly all over the whole crop. Prior prevention and ceasing of disease is a necessity step to stop further harm and proper crop production. Usually, farmers or professionals keep a close eye on the plants in order to discover and identify diseases. However, this procedure is frequently time-consuming, costly, and imprecise. We need to ameliorate and quicken the process of disease perception and its diagnosis. The main aim of this research paper is to demonstrate a Disease Recognition System that is supported by providing solutions with Fertilizer Recommendation to make plant disease spotting easier and briskly. In this research paper we are providing methodology to make use of Computer Vision with a Machine Learning Model (Convolution Neural Network) to make an effective system for plant disease detection. CNN is a form of artificial neural network that is specifically intended to process pixel input and it is used in image recognition. Overall, we are intended to provide a method using machine learning to detect the disease present in plants on a colossal scale.*

***Keywords - Convolutionla Neural Network (CNN), Colossal, Computer Vision, Disease.***

## Introduction

Every day, agriculture produces an average of 23.7 million tons of food, provides livelihoods for 2.5 billion people, and it is also the largest source of income and jobs for poor, rural households. In developing countries, agriculture accounts for 29% of GDP and 65% of jobs. The different pet animal breeds, birds and insects also directly or indirectly depend upon agricultural food for their aliment.. In addition, biodiversity directly supports agriculture systems by helping to ensure soil fertility, pollination and pest control. For these reasons, agriculture is key for producing food for a growing world population [5].

How do plant diseases impact food security? Plant diseases are a major impediment to the production and quality of important food stuff. Pests and diseases pose a threat to food security

Because they can damage crops, thus reducing the availability and access to food, increasing the cost of food. In addition, plant disease can devastate natural ecosystems, compounding environmental problems caused by habitat loss and poor land management. The most direct economic impact of a trans boundary pest or disease is the loss or reduced efficiency of agricultural production - whether it be of crops or animals - which reduces farm income. The severity of the economic effect will depend on the specific circumstances [5].

Independent of the prevention approach, identifying a disease correctly when it first appears is a crucial step for efficient disease management. Majority farmers based on their experience and knowledge try to identify plant disease and try to prevent it by applying pesticides or fertilizers on the farm. But this is not an accurate method and the wrong prevention approach might of course damage the crops. Disease identification and solution has been supported by agricultural extension organizations or other institutions, such as local plant clinics. But the cost of the process is high and most clinic labs are located in the city which makes it difficult for farmers.

A system capable of performing such tasks can play an important role in avoiding the excessive use of pesticides and chemicals, reducing both the damage caused to the environment and to the associated use of pesticides and chemicals. The growing technology in machine learning and availability of big data analysis methods has the potential to spur even more research and development in smart farming. Besides promoting higher yield crops in a more sustainable manner, it also aims to contribute to event forecasting, detection of diseases, and management of farms.

This research paper demonstrates the methodology to implement server based and mobile based approach for disease identification and fertilizer suggestion employed for disease commercial use. Several factors of these technologies being high resolution cameras, high performance processing and extensive built in accessories are the added advantages resulting in automatic disease recognition. Modern approaches such as machine learning and deep learning algorithms have been employed to increase the recognition rate and the accuracy of the results.

The literature review presented in this paper also aims to provide guidance on the development of such ML-based tools, in order to provide farmers with data-driven decision making assistance systems. In this way, farmers can be assisted with lowering the need for pesticide application and the harm that comes with it, while also preserving and enhancing crop quality and yield. This contributes to the continued availability of food to meet global population demands while doing less damage to the planet. The application of ML-based techniques has promoted the emergence of projects that have enriched the development and the evolution of smart farming . With this in mind, this article also contributes to the progression, development, and success of such projects. [1][2][3][4].

## Literature Review

Plant Disease Detection Using Cnn by Nishant Shelar1 , Suraj Shinde2 , Shubham Sawant3 , Shreyash Dhumal4 , and Kausar Fakir 5.1,2,3,4, Department of Electronics and Telecommunication, Ramrao Adik Institute of Technology, Navi Mumbai, India. [ITM Web of Conferences 44, 03049 (2022)] [ICACC-2022]. The research paper demonstrates a Disease Recognition Model that is supported by leaf image classification. To detect plant diseases, we are utilizing image processing with a Convolution neural network (CNN). A convolutional neural network (CNN) is a form of artificial neural network that is specifically intended to process pixel input and is used in image recognition. [1]

Machine Learning for Detection and Prediction of Crop Diseases and Pests: A Comprehensive Survey by Tiago Domingues 1, Tomás Brandão 2 and João C. Ferreira 3, Instituto Universitário de Lisboa (ISCTE-IUL), [ISTAR-IUL, 1649-026] Lisboa, Portugal 2 Inov Inesc Inovação, Instituto de Novas Tecnologias, 1000-029 Lisbon, Portugal [ Correspondence: tards@iscte-iul.pt] 

This survey aims to contribute to the development of smart farming and precision agriculture by promoting the development of techniques that will allow farmers to decrease the use of pesticides and chemicals while preserving and improving their crop quality and production. [2]

Convolutional Neural Networks for the Automatic Identification of Plant Diseases by Justine Boulent1, Samuel Foucher 2, Jérôme Théau 3 and Pierre-Luc St-Charles 4, Department of Applied Geomatics, Université de Sherbrooke, Sherbrooke, QC, Canada. [REVIEW article : Front. Plant Sci., 23 July 2019]. This survey allows us to identify the major issues and shortcomings of works in this research area. We also provide guidelines to improve the use of CNNs in operational contexts as well as some directions for future research. [3]

Crop: Plant Disease Identification Using Mobile by Manikanta Munnangi [Oct 18, 2019] [4]

Food production & availability - Essential prerequisites for sustainable food security M.S. Swaminathan1 and R.V. Bhavani 2, Indian J Med Res. 2013 Sep; 138(3): 383–391.[PMCID: PMC3818607] [PMID: 24135188]. This paper deals with different aspects of ensuring high productivity and production without associated ecological harm for ensuring adequate food availability. By mainstreaming ecological considerations in technology development and dissemination, we can enter an era of evergreen revolution and sustainable food and nutrition security. Public policy support is crucial for enabling this. [5]

Artificial Intelligence in Agriculture: An Emerging Era of Research Paras M. Khandelwal and Himanshu Chauhan Department of Information Technology, Kavikulguru Institute of Technology and Science, Ramtek 441106, Maharashtra, India. The current paper throws a vision of how the diverse sectors of agriculture can be fuelled using AI. It also investigates AI-powered ideas for the future and the challenges anticipated in future. [6]

## Implementation

### 1.Dataset Acquisition

What Types of Datasets Used ?

There are three types of datasets are used :

1. Dataset of leaf images taken in a plain background with controlled pixel quality which makes dataset training easier.

   Ex. [Show One from Dataset of Your Project]

**Fig. 1 :** Leaf image with plane background

2. Second dataset of leaf images contains a complex background but the object of interest means the leaf body is clear and recognizable. It's a bit hard to make a model.

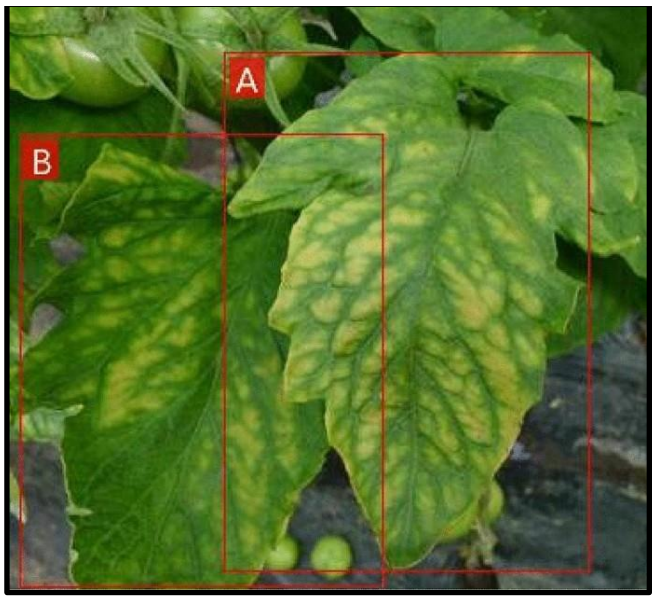



**Fig. 2:** Leaf Image with more leaf crowd

3. Third type of dataset of leaves contains more complex backgrounds which also contain other plant parts like steam, flower, etc. This type of dataset is best suited for making operational models. (Farmers and normal use prospective)

**Fig. 3:** Leaf Image With complex background

For our project proper operational implementation we wanted all above three types of leaf dataset. We used an open source dataset for our project called Plant village which contains approx 70% images taken in controlled manner and others in uncontrolled manner.

There are multiple plant datasets available on this dataset repository. We picked and downloaded according to our use.

**2.Noise Reduction**

Different sorts of filters, such as Gaussian and median filters, are used to limit noise to gain smoother images. These filters have an impact of blurring and disposing of non applicable small print of an image, at the fee of doubtlessly dropping applicable textures or edges. Erosion and dilation are two morphological photo operations that can be utilized for binary or gray-scaled images. Erosion gets rid of islands and tiny items, leaving solely large objects. In different words, it shrinks the foreground objects. On the other hand, dilation will increase the visibility of objects and fill in tiny gaps, including pixels to the boundaries of objects in an image. These operations decrease small print and beautify areas of interest. These strategies are helpful, for instance, for pest detection in opposition to an impartial background, such as photographs of traps with captured insects.

Images are normally saved in the RGB format, which is an additive coloration mannequin of red, green, and blue components. Due to the excessive correlation between these shade components, it is typically now not appropriate to operate coloration segmentation in the RGB shade space.

Therefore it is necessary to undergo in idea that there are others coloration areas such as HSV or L*a*b*. In HSV the shade aspects are: hue (pure color), saturation (shade or quantity of gray), and price (brightness). In the L*a*b* color space, L* is the luminance (brightness), a* is the fee alongside the red-green axis, and b* is the price alongside the blue-yellow axis. In these coloration spaces, the brightness of a shade is decoupled from its chromaticity, permitting the photos to be processed with special lighting fixtures stipulations [69]. This is full-size in the context of agricultural pictures received in the fields, considering they can have been shot beneath a number of light occasions or at one-of-a-kind instances of the day. Histogram equalization is an approach for adjusting contrast. In low distinction images, the vary of depth values is smaller than in excessive distinction images. Equalization of the Agriculture 2022, 12, 1350 9 of 23 histogram spreads out the depth ranges for the duration of values in a wider range. Contrast enhancement is now not immediately utilized in the RGB shade space, due to the fact it applies to brightness values. Thus, photos have to be transformed both to gray-scale or to a coloration area that carries a brightness component, such as the HSV or L*a*b* color spaces.

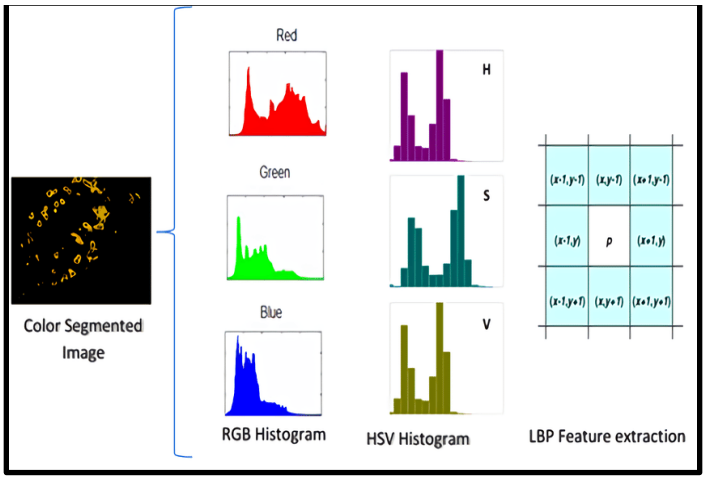



**Fig. 4:** RGB Segmentation of Leaf Image

### 3.Image Processing

Image segmentation is the technique of grouping pixels into areas of interest. In the context of crop sickness identification, these areas of hobby can be, for instance, diseased areas on the plant leaves, for assessing the severity of the contamination through the quantity of the contaminated area, or for history removal, when you consider that the elimination of the history permits highlighting of the areas of pastime for similarly analysis. Histogram of oriented gradient is a laptop imaginative and prescient approach for getting areas of pixels that share frequent properties. The homes of these regions, such as coloration and brightness, range considerably in contrast to their surroundings. This method can be used, for instance, to realize and become aware of spots in leaf images.

The k-means clustering algorithm is a famous unsupervised ML algorithm that can be used for photograph segmentation. Pixels are grouped into clusters which have pixels with similar shade and brightness values. This method is helpful, for instance, to discover broken areas on leaves. This technique is used to precisely outline the photo areas corresponding to the plant leaf components affected through disease. Intensity thresholding is a simple and simplified strategy for picture segmentation. According to the pixel value, that pixel is categorized into a team (e.g., wholesome or diseased). When the usage of this technique, photos are often transformed to gray-scale first and then thresholded the usage of a gray depth value.

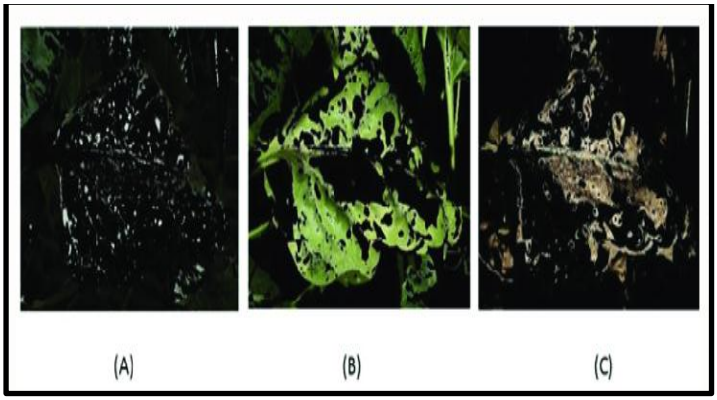



**Fig. 5:** Hu Moment to get diseased area shape

### 4.Feature Extraction

Feature extraction is a frequent step in the pre-processing of pix for shallow ML models. Common picture function extraction algorithms encompass :

1) Histogram of oriented Gradient (HoG),
2) Speeded Up Robust Features (SURF)
3) Scale Invariant Feature Transform (SIFT)

Different characteristic extractors achieve special aspects that can be greater or much less appropriate for the particular trouble at hand.

SIFT finds scale and rotation invariant neighborhood points via the entire image, acquiring a set of picture places referred to as the image's key-points. SURF is conceptually comparable to SIFT, with the gain of being a good deal

faster, which can be relevant for the implementation of real-time applications.

HoG focuses on the shape and structure of the photograph objects, by using detecting edges on pictures oriented according to unique directions. The distribution of gradients in accordance to these instructions are used as features. The histogram of oriented gradients (HOG) is an element descriptor utilized as a part of PC vision and image processing for the sake of object detection. Here we are making utilization of three component descriptors:

1. Hu moments

2. Haralick texture

3. Color Histogram

Hu moments are basically used to extract the shape of the leaves. Haralick texture is used to get the texture of the leaves and color Histogram is used to represent the distribution of the colors in an image.

Random forests are, as a whole, a learning method for classification, regression and other tasks that operate by constructing a forest of the decision trees during the training time. Unlike decision trees, Random forest overcomes the disadvantage of over-fitting of their training data set and it handles both numeric and categorical data.

The distribution of photo shades is represented with the aid of a shade histogram. Since most ailments have signs and symptoms that influence the color of the leaves, the histogram can additionally be used for distinguishing between healthful and unhealthy flora . Some pc imaginative and prescient algorithms for function extraction demand that snap shots are transformed to gray-scale, such as Haralick texture or side detection algorithms, etc. Haralick texture elements are computed from a Grey Level Co-occurrence Matrix (GLCM), a matrix that counts the co-occurrence of neighboring gray-levels in the image. The GLCM acts as a counter for each mixture of gray-level pairs in the image. Diseased and wholesome leaves have one of a kind textures in that a diseased leaf has an extra irregular floor and a healthful leaf has a smoother one. These facets permit differentiation of a wholesome leaf from a diseased one. Local Binary Pattern (LBP) is every other method used for photograph texture aspects extraction sturdy to editions on lighting fixtures conditions. Multi-spectral photograph data-sets can be exploited to create new facts and enhance the overall performance of models. For example , originally, there have been NIR snap shots of the fields and from these statistics the authors created new snapshots from spectral variations (between inexperienced and blue bands, and between NIR and inexperienced bands), band ratios and dimension discount the usage of predominant aspect analysis. The authors additionally investigate which kind of statistics achieves nice overall performance on the models.

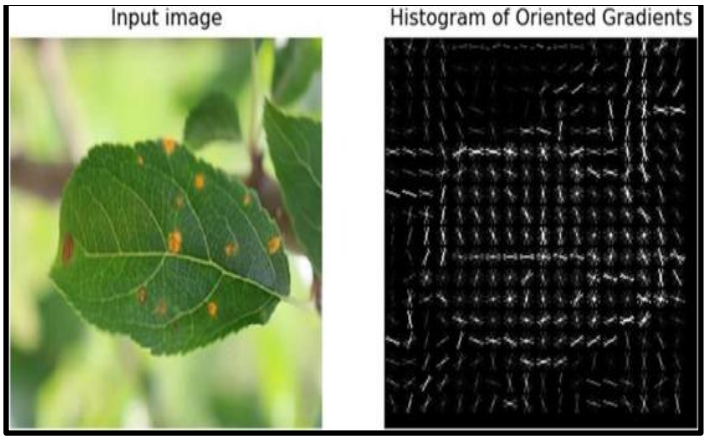



**Fig. 5:** Histogram of Oriented Gradients

**5. Data Preprocessing**

Before sending photos to the convolution neural community model, two pre-processing steps are frequently necessary. First, the pics ought to usually be resized to suit the dimension of the inner layer of the CNN. Secondly, the pics need to be normalized to assist the mannequin to converge extra rapidly as properly as to higher generalize on unseen data. Even if the use of coloration pictures helps the identification process, as the overall performance decreases solely barely at some point of the grayscale transformation, this highlights that the community depends on the whole on different aspects to become aware of diseases. . In fact, history administration is one of the difficult factors in the implementation of computerized techniques for figuring out phytosanitary troubles in imagery. With traditional picture processing methods, leaf segmentation is a preliminary step to the evaluation .Since it is the energy of the CNNs to manipulate complicated backgrounds, historical past suppression is unnecessary.

**6.Model Training**

How the PROPOSED SYSTEM is Implemented ?

We are building a neural network model for image classification. This model will be deployed on the android application for live detection of plant leaf disease through an android phone's camera. The recognition and classification procedures are depicted in Fig. 1 Fig. 1. Block Diagram Of Proposed System.

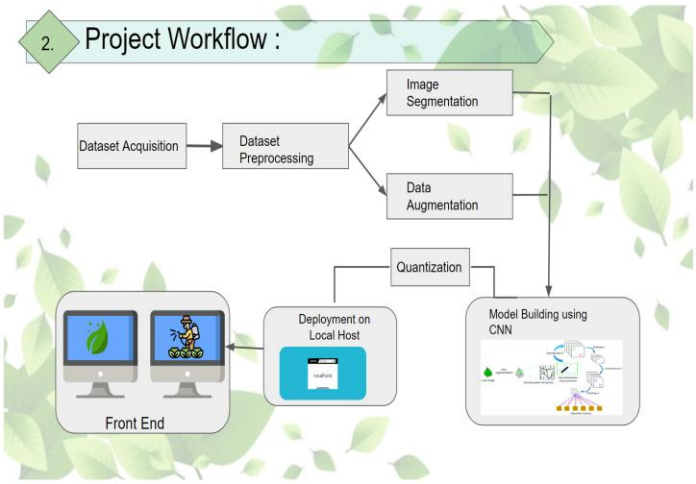



**Fig. 6:** Block Diagram

(1) The first step is to collect data. We are using the PlantVillage Dataset, which is widely available. This dataset was released by crowdAI.

(2) Pre-processing and Augmentation of the collected dataset is done using pre-processing and Image-data generator API by Keras.

(3) Building CNN(Convolutional Neural Network) Model (Vgg-19 architecture) for classification of various plant diseases.

(4) Developed model will be deployed on the Android Application with help of TensorFlow lite. 4. CONVOLUTIONAL NEURAL NETWORK ARCHITECTURE (VGG-19) Fig. . CNN Architecture

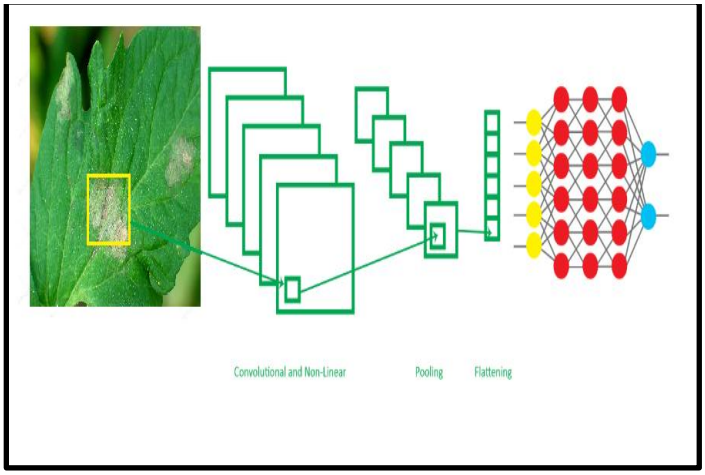



**Fig. 7:** Architecture of Convolutional Neural Network

A Convolutional Neural Network has three layers: a convolutional layer, a pooling layer, and a fully connected layer. Fig 2 shows all layers together.

1)Convolution Layer Convolutional layer: produces an activation map by scanning the pictures several pixels at a time using a filter. Fig 3 shows the internal working of the convolution layer. Fig. 3. Convolution Layer

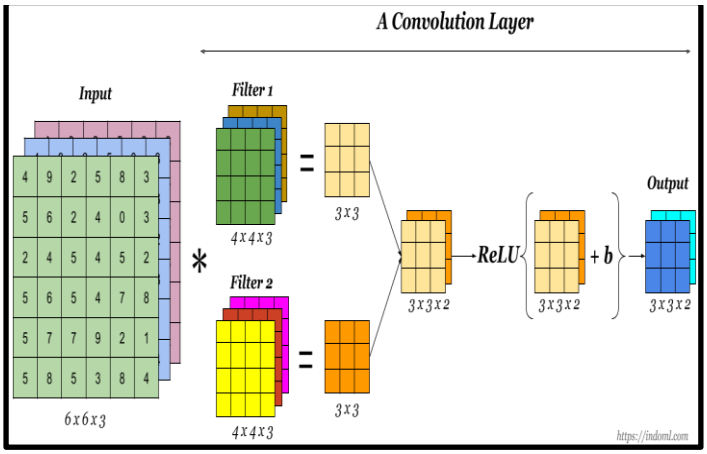
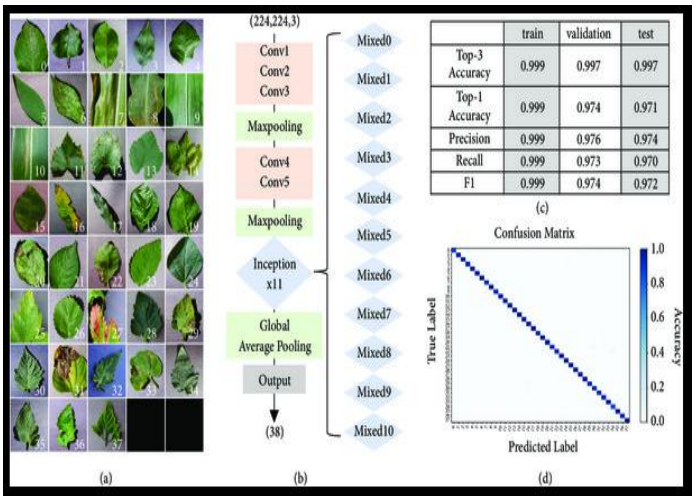



**Fig. 8:** Convolution Layer

2)Pooling Layer Pooling layer: reduces the amount of data created by the convolutional layer so that it is stored more efficiently. Fig shows the internal working of the pooling layer Fig. . Pooling Layer .




| | train | validation | test |
|---|---|---|---|
| Top-3 Accuracy | 0.999 | 0.997 | 0.997 |
| Top-1 Accuracy | 0.999 | 0.974 | 0.971 |
| Precision | 0.999 | 0.976 | 0.974 |
| Recall | 0.999 | 0.973 | 0.970 |
| F1 | 0.999 | 0.974 | 0.972 |

**Fig. 9:** Pooling Layer

4) 4.1 : Fully Connected Layer Fully connected input layer – The preceding layers' output is "flattened" and turned into a single vector which is used as an input for the next stage.

4.2 : The first fully connected layer – adds weights to the inputs from the feature analysis to anticipate the proper label.

4.3 : Fully connected output layer – offers the probability for each label in the end. Fig shows the internal working of a fully connected layer is a sophisticated CNN with pre-trained layers and a thorough grasp of how an image is defined in terms of form, color, and structure. CNN is a deep neural network that has been trained on millions of photos with challenging classification problems.

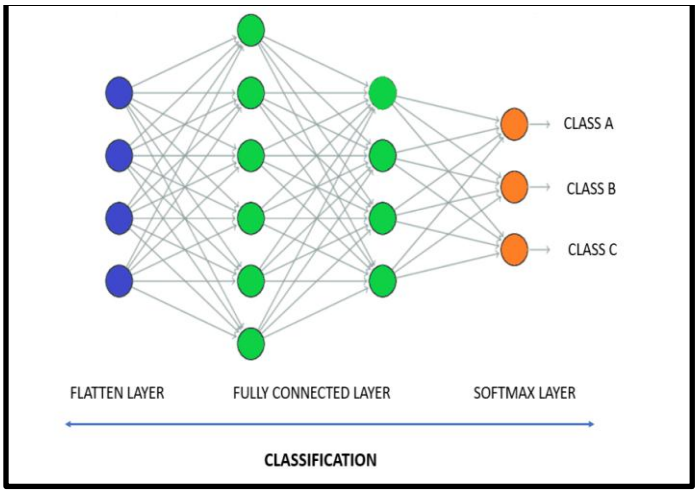



**Fig. 10:** Fully Connected Layer

**Steps :**

1. Import Libraries.
2. Load train and test data into separate variables.
3. Function to Get count of images in train and test data.
4. View number of images in each.
5. Pre-processing our raw data into usable format.
6. Generating augmented data from train and test directories.
7. Diseases Names/classes.
8. Building CNN model
9. Visualization of images after every layer.
10. Start Training CNN with Parameters.
11. Saving Model weights.
12. Predictions
13. Fertilizer Suggestion

## Providing Solution Approach

Successful detection of disease is the first step of the process. More important part is to provide and implement prevention methodology to stop further harm to the crop. This can be done by using proper fertilizers and pesticides.

## Collaborative filtering methods

Collaborative methods for recommender systems are methods that are based solely on the past interactions recorded between users and items in order to produce new recommendations.

## Content based methods

Content based methods suffer far less from the cold start problem than collaborative approaches: new users or items can be described by their characteristics (content) and so relevant suggestions can be done for these new entities.

To reduce complexity and make providing solutions easy we can develop our own page for each disease which will also contain videos and other website links to get proper and further implementation methodology.


**Fig. 11:** Fertilizer and pesticide suggestion

## Result

A ?% accuracy rate was achieved using early stopping while Training the model on ? epochs. Figure ? depicts the visualization of training and validation accuracy. The result of detecting and recognizing a plant is shown in Figure ? . On the left, a healthy plant leaf, and on the right, a sick infected plant. The result of detecting and recognizing a potato plant is shown in Figure ?. On the left, a healthy plant leaf, and on the right, a sick infected plant.

## Conclusion

We are profitable in developing ailment classification methods used for plant leaf ailment detection. A deep getting to know mannequin that can be used for automated detection and classification of plant leaf illnesses is created. More than 5 species on which the proposed mannequin is tested. 38 instructions of vegetation had been taken for identification via this work. Through this, we have been in a position to do image-processing tasks. We have been additionally capable to create the convolution neural community mannequin which is a superior convolution mannequin and instruct the mannequin with the facts for prediction. The prediction achieved by means of our mannequin is nearly correct. We have effectively deployed these fashions on the structure of a website.

## Future Use

More use and training of the model with a complex dataset will improve the accuracy of prediction. This will provide an efficient solution to the farmers. Also improved and more researched fertilizer suggestions will provide more beneficiary to the end user. Moreover if this project also gets support of hardware pathology components that will add tremendous new implementation and usefulness in the project.

Finally, it is well worth noting that the method introduced right here is no longer meant to substitute present options for ailment diagnosis, however alternatively to complement them. Laboratory assessments are in the end continually extra dependable than diagnoses primarily based on visible signs and symptoms alone, and typically early-stage prognosis by visible inspection by myself is challenging. Nevertheless, given the expectation of extra than 5 Billion smartphones in the world with the aid of 2030 of which nearly a Billion in Africa we do trust that the strategy represents a potential extra approach to assist forestall yield loss. What's more, in the future, photo information from a smartphone may additionally be supplemented with area and time records for extra upgrades in accuracy. Last but not least, it would be prudent to hold in your mind the lovely tempo at which cell science has developed in the previous few years, and will proceed to do so. With ever enhancing variety and exception of sensors on mobiles devices, we reflect on the possibility that distinctly correct diagnoses with the aid of the smartphone are solely a query of time.

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