Classification of Custard Apple Leaves Using Deep Convolutional Networks

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Abstract: Deep learning comes under the artificial intelligence does the work like the human brain in all the activities mainly in data processing and usage of those processed data in object detection, speech recognition, language translation and decision making. Convolutional neural network comes under the deep neural networks of deep learning, that is mainly applied to analyze the various images. The neural networks which are used to analyze the visual images are called as SIANN-shift invariant artificial neural networks that scan the convolutional neural networks layers and translation invariance characteristics on the basis of shared weight architecture. Forenhancedprotection of the plants from diseases, the widespread of the diseases can be controlled by early prediction of diseases in leaves. It also increased the production of the healthy plants. Since the custard apple has enormous medicinal uses, early identification of diseases in custard leaf will lead to the spread control of infection and development of healthy plants. The existing research techniques did not focused on the custard apple leaf diseases. The proposed work is an accurate predicting approach for classifying the custard apple leaves based on deep convolutional neural networks. The image dataset for custard apple leaves was created and modified general CNN architecture was used to classify the leaves. The accuracy achieved with the Adam optimizer is 85% for predicting the healthy and diseased leaves of custard apple.

Keywords: CNN, Prediction, Convolutional layers, SIANN,classification

1.Introduction

Artificial intelligence is growing nowadays in an enormous way.The robots that mimic the human characteristics, which employ the concept of artificial intelligence. AI can enclose everything starting from the algorithms used for google search to the autonomous weapons designed by IBM. Artificial intelligence is different from natural intelligence in the way that AI focuses on machines whereas natural intelligence focuses on humans and animals, which concentrates on emotions and consciousness. The difference between the two types of intelligence is that the first one is called Artificial General intelligence and the last one is called the Artificial Biological intelligence.

The part of data analysis is machine learning which automates the model building analytically. The machine learning is also a part of the artificial intelligence in which the machines can learn from the data or information and predict the patterns and also make decisions based on the human intervention.

Due to the emerging technologies the machine learning helps to predict the patterns by the training given to themand also using its own intelligence gained by the training.The algorithm for training the model should be designed by the researchers. Based on the suitable training givento the model, it predicts all the new data's which is given for testing also. That much effective training should be given to the model. Based on the effective training, the predictions which are made helps to predict the new data or thing which is again and again fed into the model. It is not a new thing but a additional invention in science.

The subset of machine learning is the deep learning in which the various layers in the neural networks act like the brain and gain knowledge from the huge amounts of data. The each layer lies in the neural network act like the neurons and each performs calculations with the data fed into it either the text data or image data and make predictions repeatedly. That repeated predictions give rise to the learning enrichment and also the outcome

accuracy will also be enhanced.The human brainalso assimilates the data and processes it through the various senses present in the human body. In the same method, the deep learning models also takes the data from various sources and predicts in real time. Deep learning takes the advancement in technology development in artificial intelligence and carried out various automation tasks without the intervention of human beings.Today almost all the products are linked with deep learning. Deep learning has lot of applications in medical field, information technology and also in emerging technologies, etc.

Consider the deep learning CNN model, which has both train and test folder. Each input picture will pass it through a arrangement of convolution layers with channels, Pooling layers, completely associated layers and after that various activation functions are applied to classify the input image with the values of 0 or 1 detected with probability.

1.1Convolutional Neural Network Design

- The convolutional neural network is constructed in such a way that multiple layers are arranged one by one from the input layer to the output layer. This network is also called as feed forward neural network.
- The hierarchical attributes can be learned from the It is the sequential design that gives permission to CNN to learn hierarchical attributes.
- The grouping layers can be followed by hidden layers and the same can be followed by activation layers in the convolutional neural networks.
- The processing that is needed before the real prediction done by the Convet is called pre processing. The preprocessing of images has to be done.
- The layers present in the convolutional network are

1. Convolution layer.
2. Max pooling layer.
3. Flatten layer.
4. Dense layer.
5. Dropout layer.

The custard apple is one of the traditional fruit of Tamilnadu state in India. Custard apple has its botanical name as Annona squamosa L.It is named as Sitaphal or Sugar apple of sweet shop and also can be called as a delicacy of dry region due to its very sweet delicate flesh. It is a shrub having multiple branches or a small tree with 3m tall. The reason for choosing custard apple is that it is having multiple health benefits. [14]They are listed as follows:

- It stabilizes the blood sugar levels in body
- Since the leaves are rich in anti oxidants, it helpful in preventing the aging of skin
- Maintains the heart as healthy one since the leaves are having potassium and magnesium content
- Boiling water with leaves helps to provide strength and power to human body
- The syrup made from the leaves are used to heal the wounds which occurred in the external parts of the human body

The leaves of the custard apple are underlying in various stages. The young yellow leaves, old yellow leaves, small leaves, holes in leaves, brown margins on leaves, dead leaves, spots or marks on leaves and black discoloration on leaves.

If the young leaves have iron deficiency, then the leaf turns yellow but the vein is in green colour. Sulphur deficiency is caused by insufficient sulphur availability. Like that,sulphur deficiency, manganese deficiency, herbicide damage also lead to leaf turning yellow. Old leaves also turned yellow because of manganese deficiency, potassium deficiency, Nitrogen deficiency, Manganese toxicity and boron toxicity. Also leaves become small due to the zinc deficiency. The holes in leaves are developed by pale green triangle butterfly. Brown margins on leaf are due to severe potassium deficiency, fertilizer burn and herbicide damage.

The leaf disease of custard apple is analyzed and from that the affected leaf is matched with the healthy leaf. The leaf patterns are taken from the public dataset and the deep convolutional networks are trained with the datasets. The convolutional architecture which gives the best result above is chosen for the detection of custard apple diseases.

The tea can be prepared sometimes with the dry leaves of custard apple mixed deeply in the boiling water. The leaves can also be heated and applied on the areas of infection to get recover from the infection. Because of these benefits the custard apple is considered as a research work.

2.**Related Work**

Tanmay A. Wagh and co in paper[1]used ALEXNET convolutional neural networks for identifying disease in grape leaves. The ALEXNET architecture is a predefined neural network. The diseases concentrated are powdery mildew and bacterial leaf spot disease. The drawback of this paper is that they have used only one algorithm for prediction. They did not compared with any existing algorithm. The accuracy obtained is 98.23%.

In paper[2], Bin liu et. al. took apple leaf images and detect the leaf diseases using the same Alexnet architecture which is used in the paper[1].the dataset includes 13,689 images which accommodates the healthy and diseased leaf. The alexnet model is trained to detect four leaf diseases such as Alternaria leaf spot,RustMosaic and Brown spot.The main disadvantage is that images are not enough for training the alexnet model and the second disadvantage is that it is more difficult to predict the correct structure of the network. The overall accuracy achieved with this model for apple disease is 97.62%.

Arivazhagan S, Vineth Iigi S. [3] have said that various diseases of mango leaf such as leaf gall, alternaria leaf spots, leaf webber, leaf burn and anthracnose are taken for prediction.1200 images of mango leaf are included in the dataset.If the farm is very small, it is very easy to detect the leaf diseases manually but if the farm is large the automatic detection is very important to predict the leaf disease in advance.The machine learning and image processing are the mainly used techniques for disease prediction before the deep learning. It has an accuracy of 96.67%. But compared with the other apple and grape diseases ,it is somewhat low. Here also one algorithm is implemented.

M. Akila, P. Deepan. [4]explained the latest technology developments made over the all fields particularly in the field of agriculture.

Rajashree Patil, Dr. Sampada Gulvani. [5]told the importance of agriculture and how the diseases affect the leaf by making holes and patches. The leaf diseases will also spread to the whole surface of the fruit and at last only the destroyed fruits and leaves will be produced from the plants. That led to the loss of economy.

Prajwala Tm and co[6] said that tomato leaves disease can be detected by using the convolution networks. The model used in the detection is Lenet architecture. The diseases concentrated are The tomato is a well known crop of India and it is cultivated in enormous quantities. The daily usage of tomatoes is in very huge quantity when compared to other crops in India. Diseases are very common in human as well as in animals and in plants. To get rid of the diseases and extend the lifetime of the plants, disease detection is necessary. The enormous Diseases are affecting the tomato plants. This paper concentrates on the convolutional neural network LeNet for identifying the diseases in plants of tomatoThe main motto of this network is to identify the diseases which minimum cost and also to use automation techniques for extracting the features, classify the diseases based on the input given to the model.This enhanced Lenet architecture achieves the accuracy of 94-95% even under the unsuitable conditions.

In paper [7] the authors developed a Lenet convolutional neural network to analyze soyabean leaf spot diseases and classify them using the affected leaf spots in the soya bean leaves. The unsupervised fuzzy clustering algorithm is used along with the LeNet architecture and it is named as VGG16.The fuzzy clustering algorithm is used for segmenting the images. The existing model achieves the accuracy rate 89.84% in testing and the poor mismatched results are shown for the 1378

images. The good results are produced for the 1271 images. But the enhanced model produces the accuracy 0f 93.54% and also the better results than previous system are produced. Only 1245 images are misclassified and 1404 images are classified correctly.

The disease which affects the leaves, fruits, roots, etc of any plant is common in agriculture. That decides the increase in production or decrease in production of the various products in the agriculture. So that diagnosis and action taken should be done at the earlier stage itself. So authors proposed a convolutional model that is also based on LeNet architecture for classifying the diseases in banana leaf. The model used here classifies the diseases at an accuracy rate of 90% and the results shown that the proposed model works under the challengeable situations namely various resolutions, background complexity, posture, sizes, nature of the real images said by Jihen Amara., et al.[8]

P.Revathi and M.Hemalatha [9] expresses their full interest in computation of leaf spot diseases in cotton plant. The reason for choosing the cotton plant is that cotton plays a major role in manufacturing cotton dresses in India and exports to almost all countries in the world. The images given by the users are tested with the images given in the databases. For that purpose, first the databases are trained with the images. The various diseases concentrated in this paper were variance in color feature, variance in shape and texture. The database with images is initialized in response to the relation with the image given by the user. The concentrated information details in the leaf are shape, variance in shape and texture. The various information collected are extracted from the leaves based on the Particular swarm optimization technique. This technique helped to identify the leaf spot diseases in cotton leaves. The accuracy is increased and error rate is reduced by using the CIGDFNN method in which divergence in colors, shape and texture are taken into consideration. For skew divergence color variance, color histogram and color descriptor method is used. For skew divergence shape feature, edge detection method is used. Gober filter and texture descriptor is used for texture feature. The diseases concentrated here are Micro Nutrient Bacterial Blight, Leaf Blight, Fusarium wilt,Root rot, Verticillium wilt. The three methods along with Cross Information Gain Deep forward Neural Network (CIGDFNN) are helpful in recognizing the cotton leaf spot diseases. The accuracy rate of 95% is achieved with the proposed model.

Jing Chen et al[10] said that, the convolutional neural networks replaced the usage of image recognition techniques in automated detection and classification of the diseases. The rapid results produced by CNN are better in the way the image recognition techniques are used. The variation in the architecture of convolutional neural network is used here. That is named as LeafNet with different sized feature of extractor filters. The main aim here is to find the diseases which mainly affect the leaf of tea plants. India is the leading exporter of tea to various parts of the world.Leafnet architecture mainly aimed at the extraction of features of tea plant diseases from various images with the help of various sized feature extraction filters. The BOVW-bag of visual words is constructed based on the leafnet architecture and that model is used to analyze the diseases, through support vector machine (SVM) and multilayer perceptron(MLP)classifiers. The accuracy of 90.16 percentages is achieved with the model created with leafnet architecture. While analyzing the individual performance of three classifiers, the leafnet architecture identified the tea plant disease more accurately as compared to the MLP Algorithm-70.77% whereas SVM algorithm-60.12%.As per the result obtained in the tea plant disease prediction, the leafnet architecture is suggested for future applications inorder to increase the accuracy and efficiency of diagnosis in tea plants.

In paper [11],the Indian economy is usually based on the development in the agriculture, since India is a agriculture country. There are no direct methods available for identifying diseases with original eyes. With the idea taken from this, the disease prediction in spinach leaves was done. The adjustment in intensity and image contrast have been done by histogram equalization technique. The minimization of contour energy was done with the help of active contour image segmentation technique. The segmentation technique produces the curve for detecting the object boundaries. The initial state of the contour is specified by the mask argument. The removal of small protrusions are initiated with the morphological operation from the segmented images. The diseased leaves of spinach are identified with the histogram oriented gradient feature extraction technique. Finally the disease classification is implemented by using the ANN architecture and that architecture also identified the diseased and non diseased leaves. This unique identification needs less time for computation.

The identification of leaf disease in mulberry plants were carried out in paper [12].The disease prediction is very helpful for the farmers in various aspects. The early prediction is useful to limit the diseases at the certain

level. And also manages the field effectively at a low cost. Majority of the mulberry plants show their symptoms of diseases in their leaves at the initial stage. The information regarding the leaf infections were analyzed by using different algorithms which is implemented in a machine. The leaf diseases assumed for detection are leaf spots and powdery mildew. The CNN with kernel model was used for automatic detection of diseased mulberry leaves. Initially the validation accuracy is very low while using a LENET model but later by increasing the layers, the accuracy rate is increased to more than 90 percent.

In paper[13],author mentioned that the diseases occurring in crops led to the damage of the plant species in many areas. But the identification of diseases is not done in fully fledged manner due to the unavailability of essential infrastructure. Owing to the invention of smart phones throughout the world, the deep learning gone to the phone-oriented detection of diseases in plants. The deep convolutional model is trained with the image dataset consisting of 9000 healthy as well as unhealthy leaves of tomato. That leaves are collected under the controlled climate conditions. Totally five diseases of tomato are considered for prediction. Prediction is made for the fully color model as well as grey scale model. The used fully color model achieved accuracy of 99.84 percent and it is increased advantage over the grey scale model.

4.Proposed Work

Dataset is created by taking photos manually. Augmentation is applied on dataset to increase the number of images. Then labeling the image and converting it into a array. Custard apple leaf diseases are identified using the algorithm of the Deep Convolutional Neural Network(CNN). The prediction is achieved through confusion matrix. Finally performance is calculated in terms of accuracy and loss.

No research has been done for custard leaf disease so far.This was the first time to do prediction in custard apple leaves. So the accuracy level is not well known. The Adam optimizer is used to get some accuracy level. The prediction as well as testing accuracy is identified by using the confusion matrix.

The flow of the proposed implementation is shown in the below diagram.

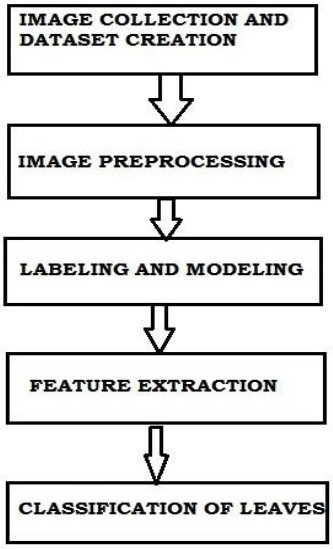


Figure 1. System Architecture

4.1 Image Collection And Dataset Creation

The images are created by taking photos of custard apple leaves manually. The minimum of 150 photos of both healthy and diseases leaves are taken. After that, the dataset is created by using the taken images. The dataset created contains only minimum images, in order to increase the size of dataset, image pre-processing is applied on the dataset.

4.2 Image Preprocessing

Since the images taken by camera or mobile may contain noises, the noises should be removed from the images with the help of the python coding. After that, the images are of different sizes, so it should be resized to 200 *200 pixels. Once it is resized, the training and testing images all are converted to a desired size.

Then the augmentation is applied to both the training and testing dataset. The image translation and reflection process are involved in augmentation, so that image quantity can be increased.

For example, the augmentation process is explained in the below diagram,

Figure 2. Images before augmentation

Figure 3. Images after augmentation

After the augmentation process is over, the images are ready for labeling and modeling.

4.3 Labeling And Modeling

In the labeling part the dataset is splitted into three parts.

1. TESTING.
2. TRAINING.
3. VALIDATION.

In testing, the images are again splitted into healthy and diseased leaves. For example, if 200 images of healthy and diseases leaves are taken. Then images are splitted in the order, 80% i.e 160 images are used in training, 20% of images i.e 40 images should be added in testing folder and validation folder.The training dataset is used for giving input to the model. When the training set is given, the model learns the features from the images. Based on the learnings, the model is going to predict the images which are given in the validation dataset. The model is evaluated with the help of validation dataset. The testing dataset should contain the new images that should not be already added in the training and validation dataset.

In all the three folders, the healthy leaves are indexed as class 1 and the diseased leaves are indexed as class 0.For training, the model used is Convolutional Neural Network architecture and compile the modelto train model automatically. There are some layers used in this coding. They are convolutional layer, maxpooling layer, dense layer, dropout layer, flattenlayer. A convolutional layer is the simple application of a filter to an input that results in an activation.

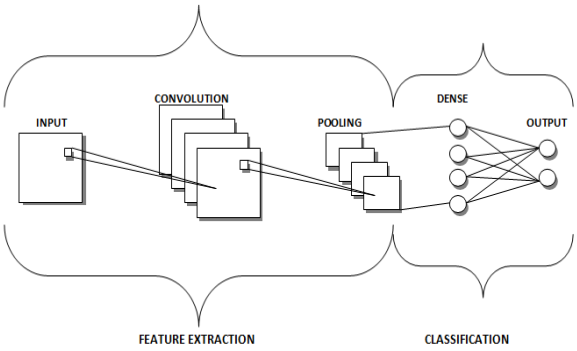
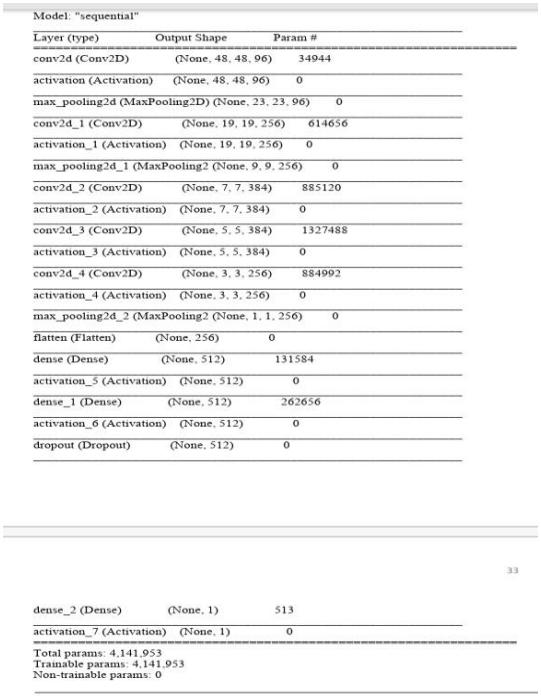


Figure 4. General CNN architecture

The pooling layer consists of average pooling layer and max pooling layer. A average pooling layer divide the input received from the convolutional layer in to pooling regions and compute the average of all pooling regions. Whereas max pooling layer divides the input into pooling regions and compute the maximum of all pooling regions. Here the max pooling layer is used.Max pooling layer is used to reduce the number of parameters used in the feature extraction.

Dense layer did the operation of connecting the one neuron with the next neuron with the input and return the output. The dense layer also can be called as a fully connected layer. The activation function attached with the flattened layer or the dens layer helps to predict the classes of the healthy leaves and the diseased leaves. A dropout layer randomly sets input elements to zero with a given probability, which is used to prevent the CNN from over fitting network. The activation function is used to predict the output of the node and it is also known as the transfer function. There are two types of activation functions such as linear activation function and non linear activation function. The mostly used activation functions are sigmoid, relu activation functions. If the output is between 0 and 1 then sigmoid function is used. The relu function will take the values from 0 to infinity, if below 0 considered as 0 and above 0 as x.

The summary of model is depicted in the following figure:



Model: "sequential"

Layer (type)	Output Shape	Param #
conv2d (Conv2D)	(None, 48, 48, 96)	34944
activation (Activation)	(None, 48, 48, 96)	0
max_pooling2d (MaxPooling2D)	(None, 23, 23, 96)	0
conv2d_1 (Conv2D)	(None, 19, 19, 256)	614656
activation_1 (Activation)	(None, 19, 19, 256)	0
max_pooling2d_1 (MaxPooling2	(None, 9, 9, 256)	0
conv2d_2 (Conv2D)	(None, 7, 7, 384)	885120
activation_2 (Activation)	(None, 7, 7, 384)	0
conv2d_3 (Conv2D)	(None, 5, 5, 384)	1327488
activation_3 (Activation)	(None, 5, 5, 384)	0
conv2d_4 (Conv2D)	(None, 3, 3, 256)	884992
activation_4 (Activation)	(None, 3, 3, 256)	0
max_pooling2d_2 (MaxPooling2	(None, 1, 1, 256)	0
flatten (Flatten)	(None, 256)	0
dense (Dense)	(None, 512)	131584
activation_5 (Activation)	(None, 512)	0
dense_1 (Dense)	(None, 512)	262656
activation_6 (Activation)	(None, 512)	0
dropout (Dropout)	(None, 512)	0

33

dense_2 (Dense)	(None, 1)	513
activation_7 (Activation)	(None, 1)	0

Total params: 4,141,953
Trainable params: 4,141,953
Non-trainable params: 0

Figure 5. Model summary

4.4 Extraction

The huge amount of data are collected and used in real life scenario. Anyhow if the details behind the data is to be analyzed, then the data should be processed. For processing the images in convolutional neural networks, the feature extraction is needed. In feature extraction, the original images sent are divided into more groups based on the dimensions and then it will be easy for processing.The major thing in feature extraction is that the characteristics of large datasets are considered as variables. That variables need some extra resources for processing the characteristics. Finally feature extraction identified the exact characteristic and combined all the variables and used it for reducing the images or data. The originality and accuracy will remain at a high rate for the images. The various features like edges, motion are extracted from the images and using the algorithm the image processing is done.

4.5 Classification Of Leaves

Once feature extraction is completed, the images are classified into different classes such as 0 for diseased leaf and 1 for healthy leaf. This classification is done with the help of the fully connected layer. The SVM classifier can also be used in the place of fully connected layer. But if the model should be trainable on end to end basis, the FC layer should be added. The FC layer uses a method to identify the classes from the identified features in convolutional layer.

5.Results and discussion

After the compilation of the model, the model is trained and validated for a batch size of 128 and epochs 10.While doing so, the accuracy and loss are calculated for both the training and validation. The training accuracy of 98.5% is achieved and the validation accuracy of 92.50% is also achieved with the adam optimizer and the general CNN architecture.

Then the separate graph is plotted for both the accuracy and loss, which are found from the prediction. The graph for training accuracy and validation accuracy is shown in the below figure, in which the x axis shows the epoch value and y axis shows the accuracy percentage for training and validation.

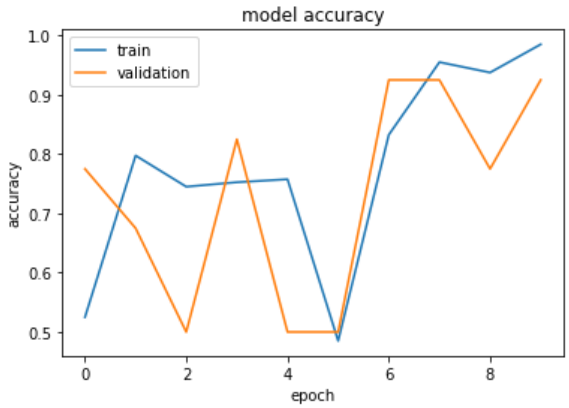


Figure 6 Model Accuracy

Similarly the graph for training and validation loss is drawn and is shown in the figure 7.The graph of loss is just a vice versa of the accuracy graph.

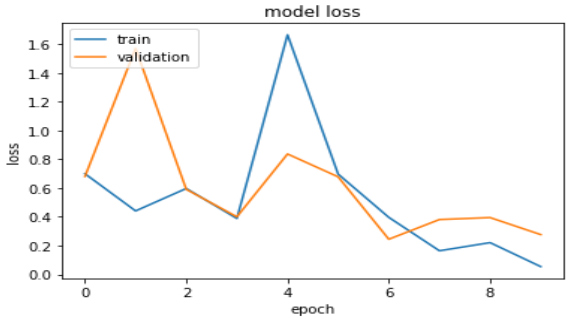


Figure 7 Model Loss

After that , the testing accuracy is calculated by using the confusion matrix. The confusion matrix use the two classes as healthy leaf 1 and diseased leaf 0. The confusion matrix for the prediction of custard apple leaves is obtained as

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array([[ 35,  5 ],
       [ 7 , 33]], dtype=int64)
```

From the above matrix, the accuracy is found by using the formula

$$\text{Accuracy} = \frac{TP+TN}{TP+TN+FP+FN}$$

where TP -true positive(healthy leaf correct prediction)
TN-true negative(diseased leaf correct prediction)
FP-false positive(healthy leaf wrong prediction)
FN-false negative(diseased leaf wrong prediction)

Based on the above formula, the accuracy of 85% is obtained for the classification of custard apple leaves.

6.Conclusions

Protection of the various crops in pesticide-free farming is a very tedious task. The complete thorough knowledge of the crops which are grown in the soil and what are all the pests applied to the crops must be known, then only a perfect solution is provided in agriculture. In this paper, the leaves of custard apple are identified as a healthy one or the diseased one with the general CNN architecture using the created dataset and Adam optimizer. The accuracy of 85% is achieved in detecting the leaf as a healthy leaf or diseased leaf. The classification of the diseases in custard apple leaves may be taken as a future work.

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