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Leaf Quality Detection for Rudimentary Urban Home Gardeners using Image Processing and Deep Learning

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Abstract – *Inexperienced gardeners in the urban areas and small lab researchers have little to no experience of plant and leaf quality and how to maintain them properly. This is the major reason why leaf quality detection can be crucial in this urban gardening. If proper care is not taken, this may result in loss of resources, money, time and efforts. For instance, if a plant's leaves' quality is dropping due to under/over usage of water, manure and chemicals, this can kill the plant. Detecting these changes and avoiding consequences using advanced computational capability like image processing and Computer vision, a part of deep learning, which includes less manual work eliminating the need for physical scrutiny, something which beginners as well as experts can use to their advantage. The paper presents algorithms for image detection, processing and identification of the quality of leaves. It also covers how computer vision, which is an important aspect of leaf quality detection, is implemented at computational level.*

Key Words: **Image processing**, **Leaf quality**, **Computer Vision**, **Organic Farmers, Gardeners, Urban areas.**

1. INTRODUCTION

Our Economy has always been dependent on farming sector. If that sector is introduced in urban areas, this can boost the economy even further. Therefore, it is important to maintain the quality of farming by monitoring it all the time. To identify the dropping quality of leaves, we need faster and powerful features much more than just brain. For example, if the leaves of a plant start dying, then the possibility of the whole plant to die is certainly very high. Because we are considering urban areas, the pollution levels will be higher than that of rural areas. The death might not be immediate but definitely inevitable. In such scenario early detection and prevention of plant deaths due to mineral deficiency, water deficiency or chemical abuse can be controlled by analysing the leaf quality with certain amount of visual computational potential.

The existing methods for leaf quality detection is very simple, which is done by a team of experts, while continuously monitoring them regularly, which is quite expensive when done on a large scale [1]. While in some places the experts are available readily, there are few places where they are in very little number making them in high demand. These types of situations are always present in some part of the world. If a technology can automatically detect the bad leaves and inform the keepers accurately, it becomes easy for urban gardeners and urban organic farmers who have limited experience with the plants.

1.1 Image Processing

Image processing is technology where we take digital images to either perform some operations on it or to extract useful information from it. The input is an image and the output will be characteristics associated with the input. This technology is gaining pace in the technical industry because of its wide variety of applications. It includes importing images, analyzing them and spotting patterns that human eye cannot see. It emphasizes on image sharpening & restoration and distinguishing the objects in the picture given.

1.2 Computer Vision

Computer vision, also known as CV, is a technology that is changing the way machines see objects. A broad term that is used to show any computations that involves visuals in it. It is one of the important parts of deep learning. The visuals can mean anything like a simple icon, an image or a video. The building block of the CV are object detection and object identification. Computer Vision is basically used now a days in handwriting or digit detection, image segmentation, scene reconstruction and image restoration. Basically, the understanding of the pixels is termed as computer vision. It's difficult to say how this algorithm works because it mimics the working of eyes and brain, which is still unknown to the scientists.

But computer vision runs on a machine and machines interpret they images based on pixels. So, it's evident that CV also uses the same kind of approach to read and process images. Each pixel has its own set of colour values. Computer vision is popular because of the type of problems it is solving. There are numerous applications of computer vision. Self-driving cars, traffic congestion detection, facial recognition, obstacle detection and many more.

In this paper, image classification of the leaf quality is done by Convolutional Neural Networks (CNN). It was proposed by Yann LeCun in 1998, it is a special type of architecture of Artificial neural network (ANN). CNN uses some visual cortex features, which is popularly used for image classification. Google, Facebook and Amazon use this on daily basis for automatic photo tagging and product recommendations respectively.

2. Literature Survey

Ghaiwat et al. in his paper, it is presented that different classification algorithms can be used to identify plant diseases. This can identify the disease but cannot identify the decreasing quality of the leaf which is very initial point of leaf decay. This is one of the drawbacks [2].

Mrunalini et al. [3] describes techniques to identify and classify various diseases by which leaves and plants are affected. The approach here for feature extraction is co-occurrence of colour. This approach also doesn't identify in initial stages, in fact, this method can be used after the leaf is hit by a disease.

Kukarni et al. represents a method for accurate and early detection of plant disease using ANN which is Artificial Neural Networks. ANN classifier gives better results with up to 91% rate of recognition. It uses texture combinations, features and colours to identify disease [4].

According to the [5] to identify plant disease, histogram matching is used. It is done on the basis of edge detection technique and also the colour feature. For training process, layer separation technique is used for the training process which also includes training these samples with red, green and blue layers and edge detection techniques, detecting the edges. To develop the colour co-occurrence texture analysis special grey level dependence matrices are used. It also comes with the drawbacks like, not being able to detect in early stages of the disease when the leaf is changing its colour or the size is shrinking.

3. Convolutional Neural Networks

The main that CNN does is, it takes input images and following definitions of the image's class. This is a skill that many people acquire from childhood and can identify things in a picture. On the other hand, computer sees pictures in a different way. From a human point of view, our brain analyses all the features and characteristics of the object and sends us the signal about the object. But a CNN has its own way of reading and analyzing the pictures, videos or logos. It can analyze any kind of picture regardless of their color, breed or size. This advanced approach is beneficial when we need to observe the features what human eye cannot catch.

Fig -1: Leaf picture

Instead of the picture, the computer sees an array of pixels. For, instance the above picture's resolution is 200x200 the size of the array will be 200x200x3. Where height=200, width=200 and 3 is the channel values of the RGB. hence the computer will see an array of pixels, something like Fig -2.

```
  0   2  15   0   0  11  10   0   0   0   0   9   9   0   0
  0   0   0   4  60 157 236 255 255 177  95  61  32   0   0 2
  0  10  16 119 238 255 244 245 243 250 249 255 222 103  10
  0  14 170 255 255 244 254 255 253 245 255 249 253 251 124
  2  98 255 228 255 251 254 211 141 116 122 215 251 238 255 4
 13 217 243 255 155  33 226  52   2   0  10  13 232 255 255 3
 16 229 252 254  49  12   0   0   7   7   0  70 237 252 235 6
  6 141 245 255 212  25  11   9   3   0 115 236 243 255 137
  0  87 252 250 248 215  60   0   1 121 252 255 248 144   6
  0  13 113 255 255 245 255 182 181 248 252 242 208  36   0 1
  1   0   5 117 251 255 241 255 247 255 241 162  17   0   7
  0   0   0   4  58 251 255 246 254 253 255 120  11   0   1
  0   0   4  97 255 255 255 248 252 255 244 255 182  10   0
  0  22 206 252 246 251 241 100  24 113 255 245 255 194   9
  0 111 255 242 255 158  24   0   0   6  39 255 232 230  56
```

Fig -2: Example of array of pixels

A value from 0 to 255 is assigned to each of the numbers, which describes the pixel's intensity. Computer looks for the base characteristics to solve the problem. Humans understand each characteristic like leaf shape, it's size, color and the texture. A computer sees this like leaf boundaries and pattern of the leaf. And the computer constructs, through few convolutional layers, the input is passed though convolutional, nonlinear, pooling layers and connected layers then output is generated.

4. Methodology

The method we used here is for the early detection of the leaf decay or dropping quality involves 2 weeks of sample collections from various areas of Hyderabad city at different temperatures and different times of the day. Healthy leaves, less healthy leaves and unhealthy leaves were collected with white background. For more accurate identification we used HD cameras to capture the image of different plant leaves which are very common among the home gardeners. Because the data set was not available on the internet, we have made our own dataset for our personal research.

4.1 Technologies used.

System used: Personal computer (PC)

Camera resolutions: 12MP – 48MP HD

Processor: Intel core i7-4600 and 8GB RAM

Operating System: Windows 10 64-Bit

Programming Language: Python 3.5.3

Environment: Jupyter Notebooks

Libraries used: numpy, keras.

4.2 Procedure

We clicked all the images and sorted them in 2 categories; healthy and unhealthy. Then we took the unhealthy leaves and sorted them accordingly like, less water content, dried edges, less chlorophyll levels, insect affected, initial stages of drying. Using the libraries, we took the photos as input and trained them.

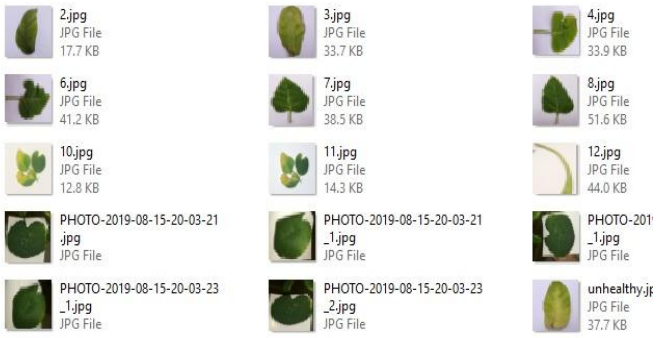


Fig -3: Data set images

The keras libraries and packages are imported first.

```
# Importing the Keras libraries and packages
from keras.models import Sequential
from keras.layers import Convolution2D
from keras.layers import MaxPooling2D
from keras.layers import Flatten
from keras.layers import Dense
```

Fig -4: Libraries and packages

The CNN building model takes four steps. Convolutional neural network is initialized using the class 'Sequential()' and making an object for this class named 'classifier' so that would be classifier = Sequential().

In the first step, we add a convolutional layer to our model.

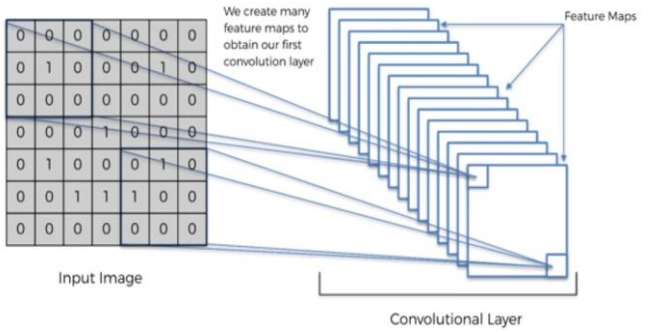


Fig -5: Convolution layers

Next step is pooling. Used for reducing the size of the feature maps. Here we are using the Max pooling.

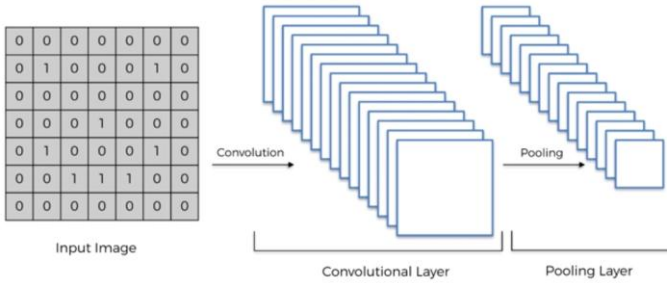


Fig -6: Pooling layer

We have to apply this because we need to reduce the nodes that will be coming in the next step, that is the flattening and full connection. If we don't reduce this size, we get too large vector and too many nodes and the model will become highly intensive. We are not losing any performance here.

The third step in convolution model is flattening, which is a 1-dimensional structure of some pixel patterns in a image.

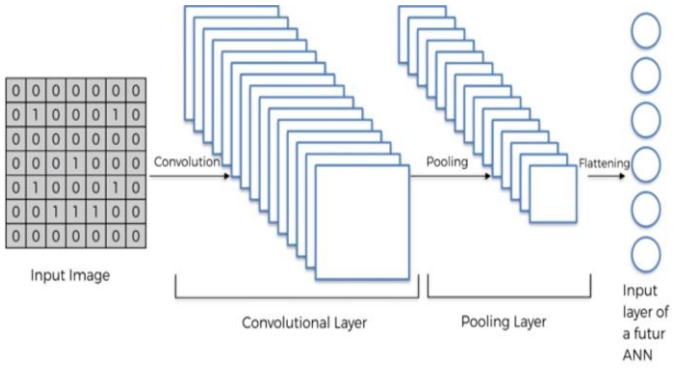


Fig -7: Flattening

The final step is full connection. Which basically makes fully connected layers. The 1-dimensional structure is fed to the fully connection input layers. In this step we also create the hidden layer with 'dense()' method.

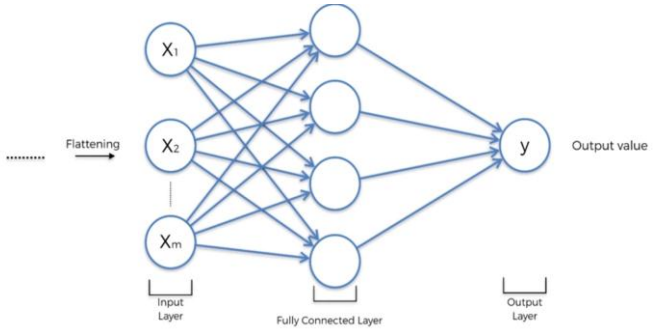
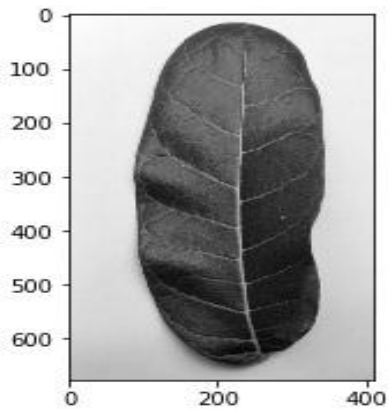


Fig -8: Fully connected

5. Results

To check whether the leaves are loaded or not we can check the leaf in a gray scale mode because RGB needs more memory.



Once we make sure that leaves are loaded properly without any errors. We continue to check if the image segmentation is working fine on the input. When we check this, the below images are generated.

Fig -9: Image just after conversion to HSV

Fig -9: Image just after applying the mask

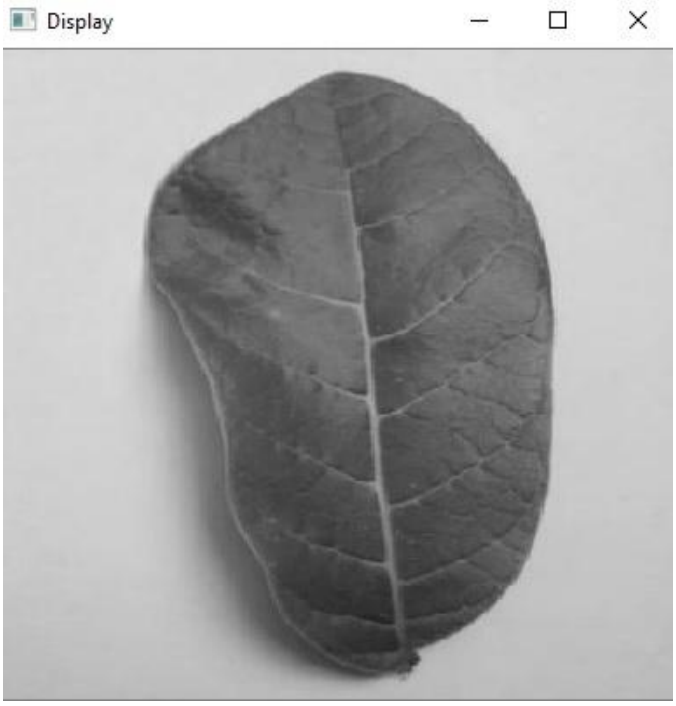


Fig -10: After HSV to Gray

Fig -11: Threshold image (final step)

This is how the algorithm gets trained with each picture it receives. The epochs are stated in the code and the algorithms trains accordingly.

The convolutional neural network is fed with the segmented images for more accuracy and the images run through the convolution, pooling, flattening and the fully connected layers.

After the epochs are completed, which we took 25 here, the algorithm shows the accuracy of the training set and valuation accuracy which determines how accurate the model is in identifying the image.

We got the accuracy of the model as 96% as seen in the fig -12 and the validation accuracy can also be seen in the graph below in fig -13.

Graphical representation of the results:

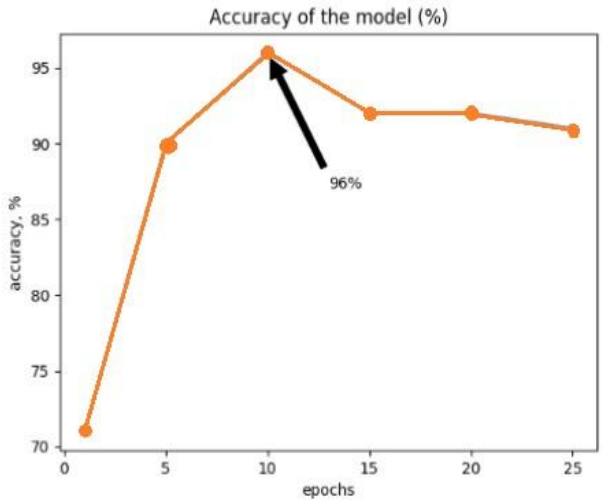


Fig -12: Accuracy of the model

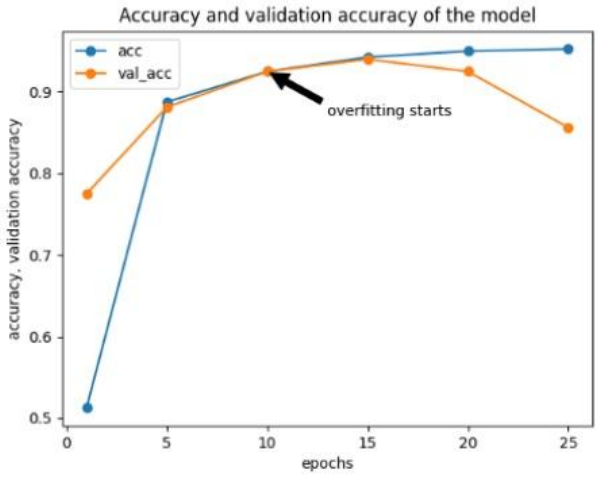


Fig -13: Accuracy and Validation accuracy of the model

3. CONCLUSION

I assembled and trained the CNN to classify the pictures of healthy and unhealthy leaves. Identification of the quality of the leaf as quickly as possible is the main purpose of the proposed work. Image processing and Convolutional Neural Networks are used to identify the quality with utmost accuracy and quicker so that the gardeners can take action and eliminate the problem. When some new picture is put as the input, the model can identify the object, that is the leaf and can tell the quality of the leaf immediately. The experimental results support the result accurately. I checked how accuracy depends on number of epochs and how just 25 epochs were sufficient to get the accuracy of 96%. I will try to collect more data and try to extend the research further in the future and would also try to improve the performance of this model.

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