A Novel Method to Detect Freshness and Edibility of Betel Leaves Using Convolutional Neural Networks

Vishwa Hatwalne, Ankit Gundewar, Siddhant Shenoy, Fedrick Francisco Pereira Neto, Malathi G

Vellore Institute of Technology, Chennai, India

Corresponding author: Vishwa Hatwalne, Email: vishwa.hatwalne2018@vitstudent.ac.in

Analyzing the edibility of consumables by the human body is very crucial to identify the nutritional values absorbed. Not consuming fresh or edible food can lead to various problems like food poisoning and low immunity. Identifying such problems at the stage of consumption can help in preventing several food borne diseases and improve health. Technology can be heavily used to determine the freshness and edibility of food items. During these pandemic times, people have been looking for food items which enhance immunity. One such item is Betel Leaf. In this research we have used techniques like Image Segmentation and Convolutional Neural Networks (CNN) to design a model which can accurately determine the freshness of the betel leaf. Image segmentation is used to extract the leaf from the image and Convolutional Neural Networks is used to extract features from the extracted leaf image. These features are then learnt by the model which classifies the leaf as the ones which are rotten and are not fresh, as 'stale' and the ones which are lush green and visibly fresh as 'fresh'. Therefore, this research would be of great use to automate the process of analyzing the freshness and edibility of the betel leaf.

Keywords: Image Processing, Deep Learning, Computer Vision, Convolutional Neural Networks, Betel Leaf, Disease Identification.

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1 Introduction

Betel leaf is a vine that belongs to the family of 'Piperaceae', which is commonly consumed in India and throughout Asia as 'Paan' paired with 'Areca Nut', also known as tobacco. Commonlyknown as 'Paan', it is most commonly consumed as a post meal digestive because of its alkalinenature which helps in balancing the pH in the stomach and in the intestines. A little-known fact isthat it contains Vitamin C, Niacin, Carotene, Thiamine, Riboflavin, and Calcium. Moreover, theseleaves are said to have excellent therapeutic potential, and these have been recorded in detail in ancient Ayurvedic manuscripts of 'Charaka Samhita' and 'Sushruta Samhita'. They have a peculiar pungent and bitter and are said to generate warmth in the body.

Unfortunately, this miraculous nutritious leaf is prone to numerous fungal and bacterial infestations resulting in rotting of leaves, spots on leaves and powdery mildew. The most traditional method used to tackle this problem is dominantly a human vision-based approach where the farmer himself or an expert is employed to exploit all kinds of symptoms or to extract some visual features that helpto identify the type of disease and degree of severity of the rotten area [1]. Additionally, there has been no industrial expansion of the betel leaf to products even when the leaf can be consumed in numerous forms like pastes, powders or juices in order to improve metabolism in a body because ofthe difficulty in sorting out the healthy leaves from the rest.

Recently an automated system was developed using an image processing approach using cognitive machine vision but even though its results were accurate, it missed out on delivering a speedy approach to the problem [2].

Therefore, to overcome the drawbacks of conventional methods and provide a swift solution, we have proposed an image processing system, backed by a Convolutional Neural Network (CNN) trained on multiple samples of healthy and rotten leaves, in this study [3].

2 Methods

A. Dataset Acquisition

For this research work to be carried out, a dataset was created from the scratch. The Leaves were acquiredfrom the local market within 12 hours of them being picked (as reported by the sellers). The leaves wereplaced in a container at room temperature and lightly sprinkled with water every 24 hrs.

Observations were recorded 24hrs apart for a set of leaves for up to 5 days. The pictures were taken in the following manner.

1. Leaf is kept under good ambient lighting conditions so as to remove shadows.
2. Camera should be kept approximately 15 cm from the leaf and in focus. (Make sure that theentire leaf is visible in the image)
3. Pictures of both the front and back of the leaf were clicked in the same condition.
4. Details such as leaf shape and venations are a must for accurate prediction.

The images were captured using a mobile with a quad camera setup consisting of a 48-megapixel primarycamera with an f/2.0 aperture; an 8-megapixel camera with an f/2.0 aperture; a 2-megapixel camera withan f/2.4 aperture, and a 2-megapixel camera with an f/2.4 aperture. This helps to record minute details such as spots, dryness, and other degradations on the leaf. Python was used to perform the image segmentation and classification.

Our dataset represents a change in quality and freshness of the betel leaves. The image (Fig. 1) below illustrates so.

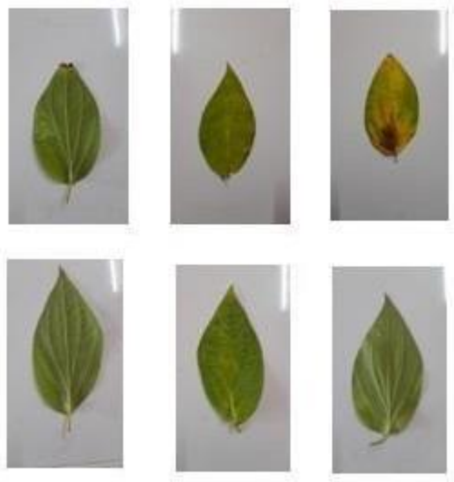

Fig. 1. Sample images from dataset

B. Model Building

It was important for us to make sure the model solely focuses on classifying the betel leaves as Stale and Fresh only. As the features of a fresh leaf and of a lightly spotted leaf do not have a lot of difference, we wanted a model to extract only the absolute necessary features and not get lost in differentiating between the leaf and the background. So 'Otsu segmentation' was used to segment the leaf (foreground) from its background [3]. Below are some images (Fig. 2), (Fig. 3) which show the segmentation.

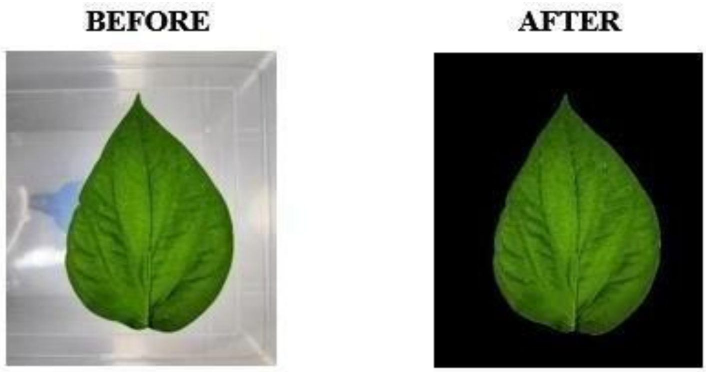

Fig. 2. The image on the left is the original image of the fresh leaf captured from the camera. The image on the right isthe segmented image where the background has been eliminated focusing solely on the leaf.

Fig. 3. The image on the left is the original image of the stale leaf captured from the camera. The image on the right is the segmented image where the background has been eliminated focusing solely on the leaf.

Once segmentation is done, the image is first converted into 400*400 dimensions, so that it can be used for further processing. For the deep learning model, the Convolutional Neural Networks (CNN) model is used. CNN is the famous deep learning algorithm majorly used for Image Classification problems. CNNbasically uses filters to convolve the images and extract the features out of it. There are 13 hidden layersand 1 output layer in this model.

Here the conv2d named layers are all the Convolutional Layers which apply the filters on the image. They convolve the image. Next layer is the Max Pooling layer. Pooling is done to reduce the spatial size of the Convolved Feature. In this case Max Pooling layer is used which takes the maximum number present in the convolved feature. So eventually by using these layers alternatively, a flatten layer is used to convert it into a single column vector. Lastly the Dense Layer with activation function as SoftMax for the classification of the leaf as Fresh and Stale is used. SoftMax basically converts a vector into a vector of probabilities. SoftMax gives the probabilities with which the leaf belongs to the two categories: fresh and stale.

Table 1. Table showing the layers of the model and their output shapes

Name of the layer	Output Shape of the layer
conv2d	(1, 398, 398, 128)
max_pooling2d	(1, 199, 199, 128)
conv2d_1 is	(1, 197, 197, 128)
max_pooling2d_1	(1, 98, 98, 128)
conv2d_2	(1, 96, 96, 128)
max_pooling2d_2	(1, 48, 48, 128)
conv2d_3	(1, 46, 46, 128)
max_pooling2d_3	(1, 23, 23, 128)
conv2d_4	(1, 21, 21, 128)
max_pooling2d_4	(1, 10, 10, 128)
conv2d_5	(1, 8, 8, 128)
max_pooling2d_5	(1, 4, 4, 128)

flatten (Flatten)	(None, 2048)
dense (Dense)	(None, 2)

3 Results

The model was trained using the dataset. The images were first segmented and then fed to the model. The model gave a training accuracy of 99.02% and validation accuracy of 100%. For loss we used the categorical cross entropy API of the Tensor Flow library. The training loss we got is 0.0389 and the validation loss we got is 0.0073.

The visualizations of the 12 layers used in the Convolutional Neural Network are as follows:

Fig. 4. Resulting accuracies from using 20 epochs for the CNN model

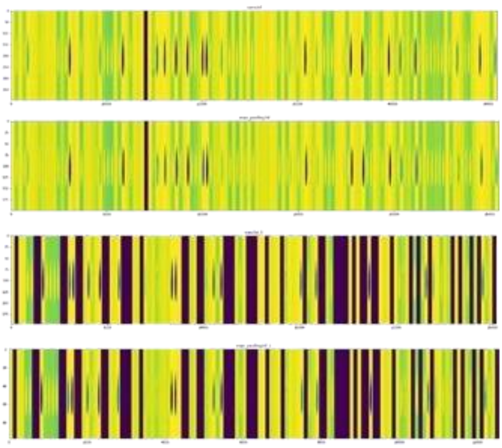

Fig. 5. Figure visualizing the first and second, convolutional and pooling, layers

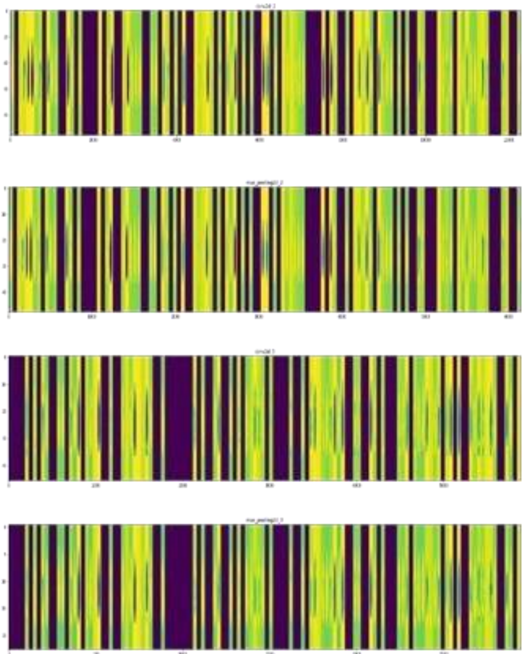

Fig. 6. Figure visualizing the third and fourth, convolutional and pooling, layers

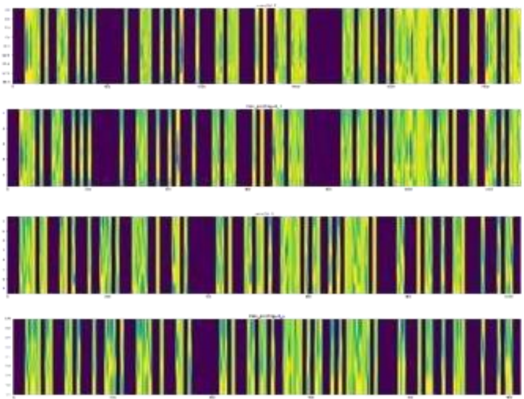

Fig. 7. Figure visualizing the fifth and sixth, convolutional and pooling, layers

4 Discussion

Thus, a model has been built and trained to differentiate the stale betel leaves from the fresh betel leaves. The model efficiently classifies and could be used in automating the process of identifying fresh and ediblebetel leaves in industries or any such large-scale usage.

References

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