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Fruits Quality Detection System

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Abstract—Manual sorting of fruits into fresh and rotten is a very long and tedious task. It can also lead to inaccurate results if not inspected properly. This research paper proposes an automated system which will classify fruits as ripe or rotten based on their appearances. This study uses a dataset consisting of fresh and rotten images of six fruits - apples, oranges, bananas, pomegranates, mangoes and grapes. The proposed model utilizes the computer vision technologies such as convolutional neural networks to produce near to perfect predictions for all different types of classes.

Keywords—fruits quality detection; ripe vs rotten; computer vision; CNNs.

1. Introduction

Following the green revolution in India that took place around the mid 1960s, India became an agriculture-based country. Agriculture accounts for more than 80% of rural India's livelihood. India is the second largest nation in terms of production of fruits. Fruits play a vital role in a person's diet. Different fruits are rich in vitamins and minerals and are a proven source of reducing risks of chronic diseases in humans.

With the increase in industrialization, the use of modern agriculture tools like pesticides and fertilizers has increased exponentially. This also poses few health concerns when it comes to the quality of fruits. Partially rotten fruits can contain harmful pathogens which can affect the human body in different ways.

Pre-harvesting is done manually in most cases. These practices include sorting and grading the fruits based on their appearance. This may lead to inaccurate results lead-ing to supply of rotten fruits to the end customers. This paper proposes an automated system that replaces manual segregation. An automated system removes the hassle and time-consuming manual labour. Automation has proved to be of great use in the field of agriculture. With the recent advancements in deep learning and computer vision tech-niques, creating and deploying models has become easier than ever.

Computer vision is a field of artificial intelligence that trains computers to understand the real world objects. Com-puter vision includes several steps of processing images or videos and producing relevant outputs. Data is acquired from different sensors or through open source datasets available online. This data is processed using different algorithms. Analysis is done on data to extract meaningful information out of it.

The dataset used for this study contains images of ripe and rotten fruits- apples, bananas, oranges, pomegranates, mangoes and grapes. These images were of a similar resolution with each of them being rotated by some angle to ensure easier feature extraction.Figure 1 shows a sample collection of images from the dataset. This paper focuses on classifying the fruits in twelve different classes based on multiple features like color, intensity, shape and size. Fruit classification as rotten or ripe has been a hot topic in field of computer vision. [1] study focused on classifying oranges as ripe, unripe or rotten based on decision tree clas-sification. Another study [2] focused on predicting vegetable quality using different segmentation techniques such as color based and edge detection. This study mainly focuses on image classification using Convolutional Neural Networks which resulted in near-to-perfect accuracy which was never achieved before.

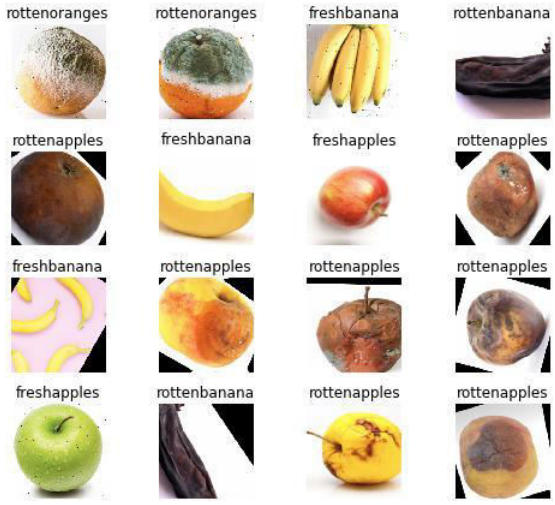

Figure 1. Sample images from the dataset

2. Materials and Methodology

2.1. Materials

The dataset used in this study is freely available on [3] and consists of a total of 13599 images. These images are subdivided as fresh apples(2088), rotten apples(2943), fresh bananas(1962), rotten bananas(2754), fresh oranges(1854) and rotten oranges(1998). Each image is roughly of 450 x 450 pixels resolution with each image occupying approximately 180 kilo bytes of space on the disk. In addition to this, an additional dataset for the remaining three fruits-pomegranates, mangoes and grapes, was created using images from google search consisting of a total of 1083 images. These images are subdivided as fresh pomegranates(132), rotten pomegranates(218), fresh mangoes(133), rotten mangoes(230), fresh grapes(169) and rotten grapes(201).

2.2. Methodology

Convolutional Neural Networks(CNNs) are powerful deep learning methods used in image processing, machine learning and computer vision problems. A neural network consists of a network of neurons that have learnable weights and biases. Neural networks take in a raw image as the input and output the class predictions.

A convolutional neural network is made up of multiple types of layers - Convolutional layer, Pooling layer and Fully connected layer. These layers are stacked together to form a convolutional network architecture. Figure 2 shows how the layers are connected in a convolutional network.

2.2.1. Convolution Layer. The input array of image pixels is fed to the convolutional layer. This layer consists of filters to extract the low level features. These filters convolve or slide over the pixel array and multiply the values in the filters with the original pixel values and results are summed to output a single value. This process repeats for each location in the input image. This ultimately creates an array of numbers called as feature map or activation map.

2.2.2. Pooling Layer. The pooling layer operates over the feature maps obtained from the convolutional layer. Its function is to reduce the size of the representation arrays to a smaller dimension in order to reduce the computation and parameters involved. The most commonly used pooling technique is Max Pooling. Under this method, a filter of a fixed size slides over the feature maps array and extracts the maximum value from every window while sliding.

2.2.3. Fully Connected Layer. The final layer of a convolutional network architecture is the fully connected layer. Neurons in a fully connected layer have connections to all the activations in the previous layers. This layer outputs a N-dimensional vector that contains probabilities for each of the N labels.

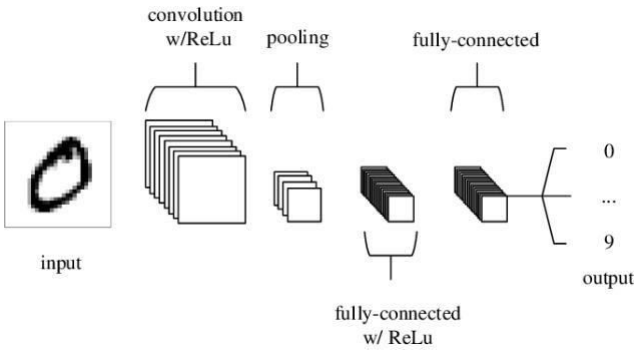

Figure 2. CNN Layers

3. Experimental Results

The neural network model used for this study is ResNet(Residual Network) model. ResNet makes it possible to train up to hundreds or even thousands of layers and still achieves compelling performance [4]. ResNet is particularly useful when it comes to computer vision applications. ResNets can solve the issue of vanishing gradient. This problem arises when the network is too deep and the gradients slowly becomes zero and the weights are never updated. Because of this, the model stops learning. Using ResNets, the gradients can flow directly through the skip connections backwards from later layers to initial filters.

The dataset containing ripe and rotten images of six different fruits was carefully filtered and cleaned to remove noise which could hamper the accuracy of the model. Images of low resolution, clarity and unnecessary background were removed from the dataset. The entire image pixels array was normalized and rescaled to a size of 224 * 224 pixels. The ResNet-18 pre-trained model was run to train on this dataset. The accuracy achieved are shown in the table below.

Fruit	Fresh class Accuracy	Rotten class Accuracy
Apples	100	99.6
Bananas	100	100
Oranges	100	99.7
Pomegranate	97	94.6
Mangoes	95.8	97.9
Grapes	94.1	92.7

Table I: Success rates of different fruit classes with ResNet-18 model.

The overall accuracy achieved for the fresh class comes out to be 97.8 and for the rotten class comes out to be 97.4. In other recent study [5], the maximum accuracy achieved for fresh and rotten fruit classification was 98.1 and 97 respectively considering three different types of fruits.

The confusion matrix in Figure 3 for the latter three fruits indicates the number of correct and wrong predictions made by the model. The maximum times a fruit class was incorrectly predicted was two - model predicted rotten grapes as rotten pomegranates. Other incorrect predictions were made when the model confused fresh grapes with

fresh mangoes(1), fresh grapes with rotten grapes(1), fresh mangoes with rotten mangoes(1) and a few more similar cases.

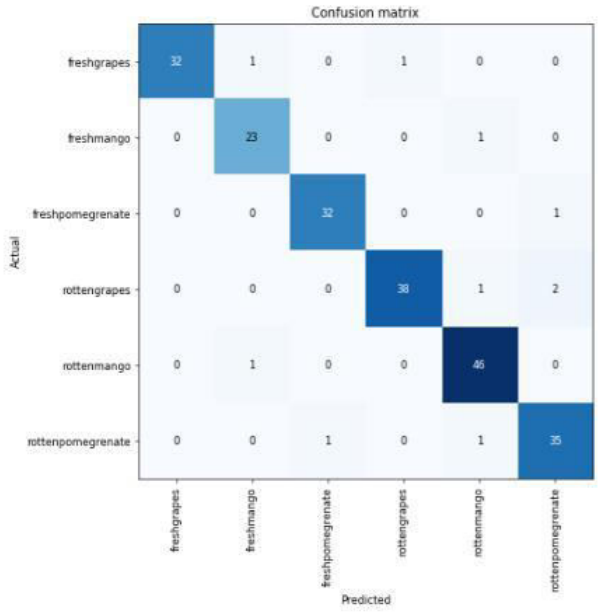

Figure 3. Confusion matrix for pomegranates, mangoes and grapes

4. Conclusion

Automated vision based systems to distinguish fresh and rotten fruits (also among different fruits) would significantly decrease food waste, diseases related to food-borne and economic loss [6]. In this study, we differentiate between the rotten and ripe categories of six different fruits - apples, bananas, oranges, pomegranates, grapes and mangoes. Using the ResNet-18 model, we can achieve near to perfect accu-racy for predicting each label of fruit. By using a more effi-cient model(ResNet-34 or ResNet-50) and obtaining higher quality and quantity of images, this accuracy can be further improved in the future.

References

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