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Deep Learning based Fruit Quality Inspection

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Abstract: Digital images and computer sciences have become two powerful tools in several areas, such as astronomy, medicine, forensics, etc. In the last few years, computer sciences are getting involved in agricultural and food science to decide based on estimated or actual parameters named features. Rottenness is the state of decomposing or decaying the quality of the fruit, which not only affects the taste and appearance but also modifies its nutritional composition, causing the presence of mycotoxins dangerous for humans. Detecting rotten fruits has become significant in the agricultural industry. Usually, the classification of fresh and rotten fruits carried by humans is not effective for the fruit farmers. Human beings will become tired after doing the same task multiple times, but machines do not. Thus, the project proposes an approach to reduce human efforts, reduce the cost and time for production by identifying the defects in the fruits in the agricultural industry. If we do not detect those defects, those defected fruits may contaminate good fruits. Hence, we proposed a model to avoid the spread of rottenness. The proposed model classifies the fresh fruits and rotten fruits from the input fruit images. Here, we use a trained deep learning model i,e sequential model to detect whether a fruit is fresh or rotten. In this work, three types of fruits, such as apple, banana, and oranges are used as a dataset. The experiments were done using a dataset composed of around 12000 images divided by 6 classes, 3 fresh fruits, and 3 rotten fruits

I. INTRODUCTION

India is an agricultural country. Different types of fruits and vegetables are produced in India. India is at the second number after China in the production of fruits. In India, all the pre-harvest and post-harvest processes are done manually with help of labor. The manual process is very time-consuming, less efficient so to get accurate results automation in the agriculture industry is needed. The post-harvest process includes sorting and grading of fruits. Different quality factors are considered for the sorting and grading of fruits. These factors are internal quality factors and external quality factors. The external quality factors are texture, shape, color ,size and volume, and internal quality factors are test, sweetness, flavor, aroma, nutrients, carbohydrates present in that fruit

A. Context

Automation is playing an important role in today's life. In India, more than half the population depends upon agriculture. Their main source of income is agriculture. Exporting fresh fruit is increasing day to day from India. People are very conscious about their health; they prefer only fresh, good quality fruit. Quality evaluation of agricultural products is most commonly conducted using destructive methods. The destructive method enables us to measure texture, colour, sugar content, etc. Destructive methods increase the success rate of quality determination of fruits; however, it practically has many concerns about effectiveness, reliability and cost. Therefore, it is necessary to develop fast, portable and cost-effective techniques without harming fruits to meet the demand of consumers for fresh and healthy fruits.

Generally, lots of vegetables and fruits are transported across different states. Some of the fruits may get damaged or rottened during the transportation. Its a very time consuming task for a human to categorize fresh fruits and rotten fruits. It requires some man power. If a fruit gets rotten in a bunch, then there is a chance for other fruits ro get rotten. So, separating the rotten fruits from the fresh fruits is an essential task. By this, we can get rid of the damage. According to a survey, 16% of fruits of the production are getting wasted. There is a necessity to cover the loss so that lots of farmers and dealers get profit.

Fruit dealers get large quantities of fruits from different states. Lots of fruits are transported across lorries. Each and every fruit is checked manually and whenever a rotten or damaged fruit is identified, they are separated. But, as there are large quantity of fruits, looking at each and separating the rotten fruits from them is a time consuming process and requires man power. Even if a single rotten fruit stays in a bunch of fruits, all the other fruits neighbouring to it also get rotten which is a huge loss to the fruit seller.

The fruits are to be moved on a conveyor belt one by one. This system collects images from a camera which is placed on a conveyor belt. Then image processing is done to get the information if the fruit is good or rotten. As the deep learning model is trained with thousands of rotten and fresh fruit images, if the camera detects any fruit that is rotten or damaged, it can be separated immediately and moved out of the conveyor belt.

II. LITERATURE SURVEY

A. *Segmentation Techniques for Rotten Fruit detection*

K. Roy, S. S. Chaudhuri, S. Bhattacharjee, S. Manna and T. Chakraborty [March 2019]

Segmentation technique to detect a vegetable's quality is a very useful method. An automated system if coupled with such technique would be very helpful in sorting the fresh and the rotten vegetables. The purpose of this research paper is to provide an approach for the segmentation of the rotten vegetables to annihilate infirmity with respect to human health. Segmentation techniques such as Marker Based Segmentation, Colour Based Segmentation and Edge Detection, produced promising and effective results. Through the above mentioned segmentation techniques, the rotten portions of a vegetable are detected effectively to separate the unhealthy vegetables from the good ones.

B. *Detection of Quality in Orange Fruit Image using SVM Classifier*

H. Patel, R. Prajapati and M. Patel [April 2019]

Non-destructive quality assessment of Fruits is essential and exceptionally fundamental for the life sustenance and rural industry. The Fruits in the market are ought to fulfill the buyer inclinations. Generally, the reviewing of Orange fruit is done by the visual examination and by utilizing the size as a specific quality characteristics. Picture preparation offers answers for computerized Orange Fruits estimates on solid, predictable and quantitative data which are separated from dealing with extensive volumes that may not be accomplished by utilizing the human graders. This Research shows an Orange size and Bacteria Spot Defect distinguishing and reviewing framework which is dependent on the picture preparing.

C. *A real-time smart fruit quality grading system classifying by external appearance and internal flavor factors*

H. S. Choi, J. B. Cho, S. G. Kim and H. S. Choi [Feb 2018]

The fruit grading by visual inspection suffers from the problem of inconsistency in judgment by different persons. There is a need for an automatic fruit classification machine replacing the expensive human labor with a smart fruit quality classification system. This study proposed a practical real-time smart fruits quality grading system classifying by appearance and internal flavor factors in order to decrease human labor cost in fruit industry. The proposed system applies color image processing techniques for the computation of the fruits appearance features and the near-infrared spectroscopy analysis methods for the estimation of internal flavor factors. This study also suggests an artificial neural network model in order to be able to classify fruit grading. The proposed ANN model is trained and tested with 1,900 numbers of pears for grading.

III. FRUIT QUALITY INSPECTION SYSTEM DESIGN

A. *Architecture*

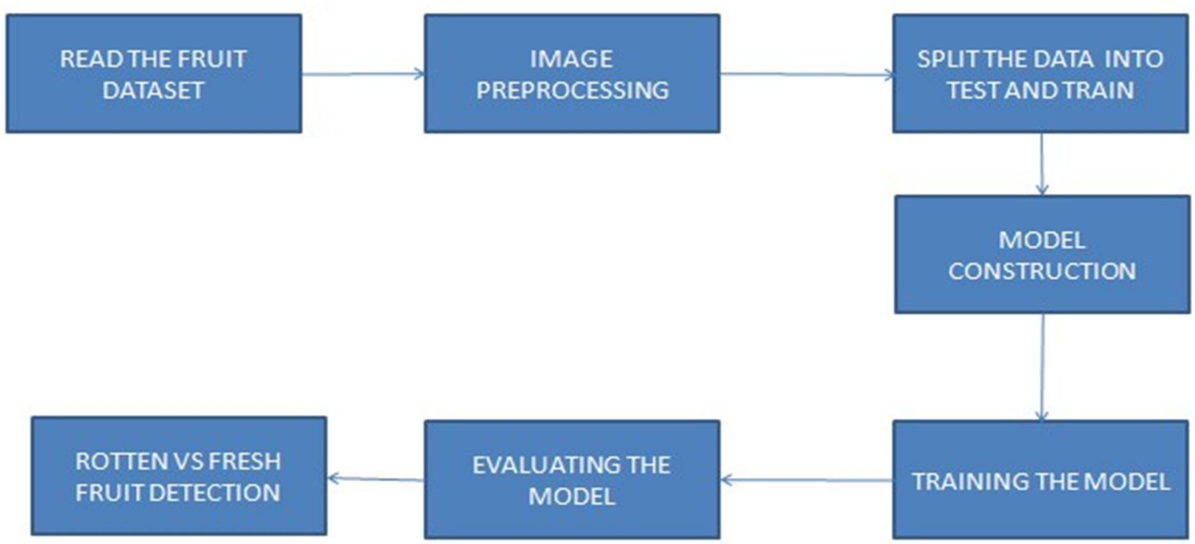

Fig 3.1: Block Diagram of Fresh and Rotten fruits Detection

The above block diagram 3.1 shows a simple block diagram of how the Fresh and Rotten fruits identification process takes place. First Image Data Set need to be read from Storage/Database, Different image sizes are not accepted for Model Training, So, all images need to be transferred to some fixed size it is done by Image Preprocessing, in Image Preprocessing we have reshaping the image, crop, rotation, changing into RGB etc., can be done.

In the next step we divide the image data set into training and testing data sets. Next, using a preprocessed training image data set we train the model. After training the model we evaluate the model using testing image data set. After the evaluation of model we get accuracy which indicates how well the model can predict.

The images given to the training dataset are used for training the model and when an input image is given, it is initially scaled to predefined size for easy computations and then

Sequential model is used to classify the fruits.

Initially various images consisting of banana, Apple, Orange images are collected.In this project all the images are resized to the dimensions 100 x 100.After scaling, we get the images of the same size which helps in analyzing and testing the system easily. Then the data set is divided into training and testing sets.

The images are converted into numpy arrays in which all of its fields consist of the pixel values. All these arrays are grouped together as a Numpy array dataset and then they are labelled across each image indicating whether the image is fresh or not.

The system classifies the fruit images if they are rotten or else damaged.

B. Dataset

Choosing the right dataset which would work best for the Sequential model required a little effort. The dataset used in training the model in a given approach was a combination of various open-source datasets and pictures, which included data from the Kaggle's Fruit Dataset. The dataset includes about 1693 fresh apples, 1581 fresh bananas, 1466 fresh oranges, 2342 rotten..

IV. RESULTS

To test data first, we should train the data set using an algorithm. After training the dataset with algorithms we should test the dataset with the same algorithms and check the accuracy of each algorithm and predicted values of each algorithm.

First we have divided the data set into 6 different categories i,e fresh apples, fresh banana, fresh orange, rotten apples, rotten banana, rotten oranges. As the data set is divided into train data set and test data set, the train data set contains 10901 images of 4740 fresh fruits and 6161 rotten fruits. The test data set contains 2968 images of 1164 fresh fruits and 1534 rotten fruits.

The system detects whether the given image is a fresh fruit or not. Testing is done by initially pre-processing the given input images by resizing them to desired size. Once the testing is done, the results of the test are given so that necessary actions can be taken. The below figures 4.1 shows the rotten fruit images and 4.2 shows the fresh fruit images.

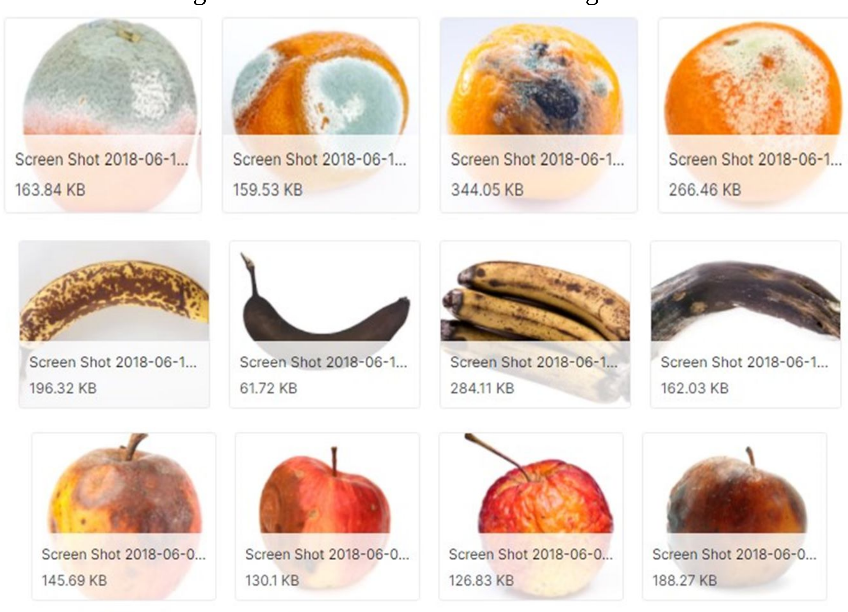

Figure 4.1: Rotten fruit dataset

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Figure 4.2: Fresh fruit data set

The below figure 4.3 shows the training report. The model is trained with 10 epochs. The accuracy is 97%.

```
history=model.fit(X,Y,batch_size=20,validation_data=(X_val,Y_val),epochs= 10,
                  callbacks=[check_point])

Epoch 1/10
546/546 [==============================] - 519s 917ms/step - loss: 0.7065 - accuracy: 0.8198 - val_loss: 1.0261 - val_accuracy: 0.8892

Epoch 00001: val_loss improved from inf to 1.02607, saving model to /kaggle/working/rotten.h5
Epoch 2/10
546/546 [==============================] - 505s 925ms/step - loss: 0.2302 - accuracy: 0.9139 - val_loss: 0.8249 - val_accuracy: 0.8213

Epoch 00002: val_loss improved from 1.02607 to 0.82489, saving model to /kaggle/working/rotten.h5
Epoch 3/10
546/546 [==============================] - 504s 923ms/step - loss: 0.1538 - accuracy: 0.9443 - val_loss: 0.1691 - val_accuracy: 0.9544

Epoch 00003: val_loss improved from 0.82489 to 0.16914, saving model to /kaggle/working/rotten.h5
Epoch 4/10
546/546 [==============================] - 503s 921ms/step - loss: 0.1488 - accuracy: 0.9519 - val_loss: 0.1830 - val_accuracy: 0.9485

Epoch 00004: val_loss did not improve from 0.16914
Epoch 5/10
546/546 [==============================] - 511s 935ms/step - loss: 0.1214 - accuracy: 0.9564 - val_loss: 0.1754 - val_accuracy: 0.9422

Epoch 00005: val_loss did not improve from 0.16914
Epoch 6/10
546/546 [==============================] - 508s 930ms/step - loss: 0.1022 - accuracy: 0.9650 - val_loss: 0.0862 - val_accuracy: 0.9692

Epoch 00006: val_loss improved from 0.16914 to 0.08625, saving model to /kaggle/working/rotten.h5
Epoch 7/10
546/546 [==============================] - 499s 914ms/step - loss: 0.1204 - accuracy: 0.9589 - val_loss: 0.2950 - val_accuracy: 0.9129

Epoch 00007: val_loss did not improve from 0.08625
Epoch 8/10
546/546 [==============================] - 501s 917ms/step - loss: 0.0865 - accuracy: 0.9693 - val_loss: 0.0834 - val_accuracy: 0.9681

Epoch 00008: val_loss improved from 0.08625 to 0.08342, saving model to /kaggle/working/rotten.h5
Epoch 9/10
546/546 [==============================] - 501s 918ms/step - loss: 0.0868 - accuracy: 0.9694 - val_loss: 0.1883 - val_accuracy: 0.9422

Epoch 00009: val_loss did not improve from 0.08342
Epoch 10/10
546/546 [==============================] - 503s 922ms/step - loss: 0.0702 - accuracy: 0.9742 - val_loss: 0.0792 - val_accuracy: 0.9763
```

Figure 4.3: Training report

The below figure 4.4 shows the predictions on some images. These are the classifications made by the Sequential model. Each and every image is classified to fresh fruit or a normal fruit. The accuracy of this model is 97%.The model learns from the pattern of train dataset and labels and then makes classifications. These images are randomly chosen from a set of testing images folder and passed through the CNN model in order to identify the fresh and the rotten fruits. This model can classify 3 types of fruits.

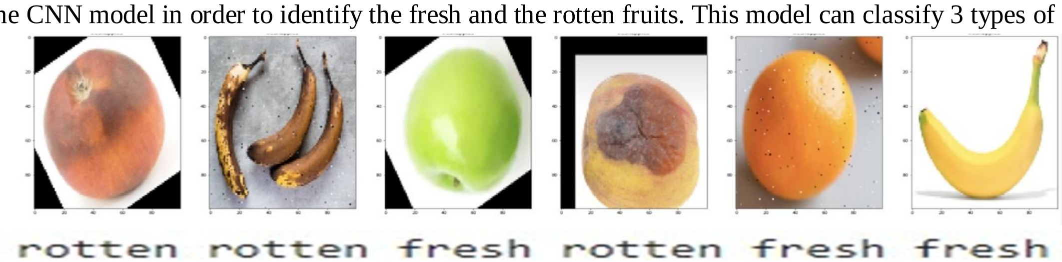

Figure 4.4 Detection of fresh fruit and rotten fruit

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V. CONCLUSION AND FUTURE SCOPE

A. Conclusion

The classification of fresh and rotten fruits is very important in agricultural fields. Separating the fresh fruits and the rotten fruits is a time consuming process and lot of manpower is required.Here, a Sequential model is trained with rotten fruit dataset and fresh fruit dataset.The model is able to differentiate the fresh and rotten fruits o 3 different types.The effects of different hyper-parameters i.e. batch-size, number of epochs, optimizer, and learning rate are interrogated in this work. The results proved that the model proposed can classify fresh and rotten fruits firmly and produced better accuracy than transfer learning models. Thus, the proposed model can automate the process of the human brain in classifying the fresh and rotten fruits with the help of the proposed convolutional neural network model and thus reduces the human errors while classifying fresh and rotten fruits.
The accuracy of 97% .

B. Future Scope

In the future, the large dataset of fruit images can be considered to validate our proposed model on it. So, many other fruits also can be identified.

This project can also be extended in identifying the disease of the fruit.A farmer can directly take a picture of the fruit from his mobile and check what type of disease the tree or plant is affected with.

We can get more accuracy if we increase the number of images in the data set.We intend to make this model more robust and accurate by using more such images.

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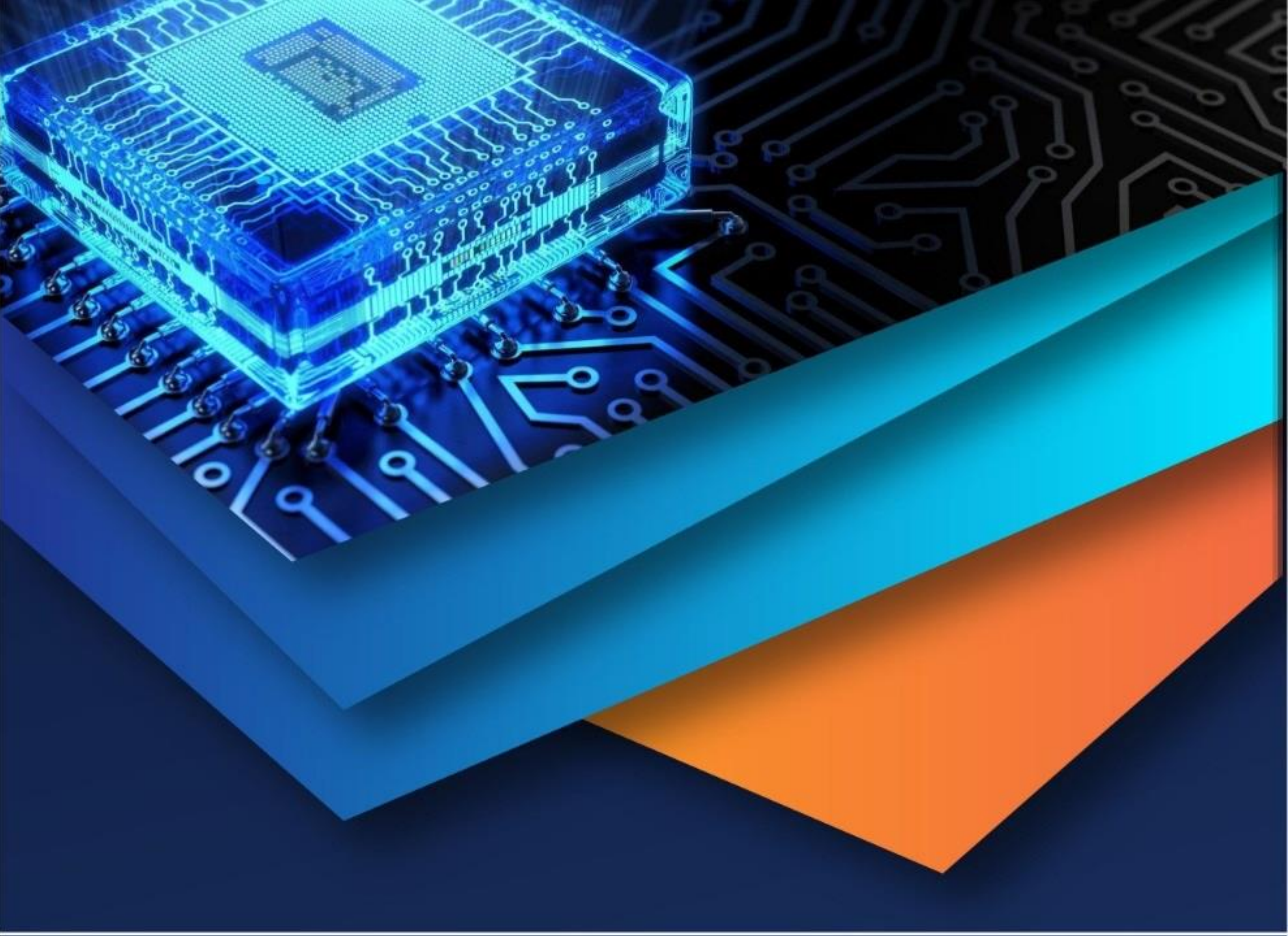

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