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Detection of fruit ripeness using image processing

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Abstract---Cultivation of fruit crops plays a very important role within the prosperity of any nation. Productive growth and high yield production of fruits is necessary and required for the agricultural industry. To understand ones health, it is better for agriculture agents to check ripeness of fruits naturally and in organic way. So that one can have fresh and natural fruits at their doorsteps. In this paper we introduce ripeness of fruit using a new, high-quality, dataset of images containing all type fruits. We also present the results of some experiment for training a digital image processing to detect fruits. We discuss the In fruit during ripening there is a well-coordinated series of changes in the composition of the fruit which lead from the unripe to the ripe condition and which give obvious changes in colour, texture, taste, time to ripe and aroma which are readily perceived by the senses.

Keywords---digital image processing, image detection, VGG16 model, fruits dataset, image classification.

Introduction

The making of a fruit is also a development process unique to fruits. It requires a elaborate network of interacting genes and signaling pathways. In fleshy fruit, it involves some distinct stages, namely, fruit set, fruit development, fruit classification, fruit image detection and fruit ripening. The ripening has received most attention from people working in this area, as the necessary process to activates a whole set of biochemical in the path that make the fruit more attractive, desirable, and edible in nature for consumers. In recent years, the scientific goal has been to reveal the mechanisms by which nutritional and sensory qualities is developing during fruit development and ripening. The classification of fruits is useful in supermarkets where prices for fruits purchased by a client can be defined automatically. Fruit classification can also be utilized in

computer vision for the automatic sorting of fruits from a set consisting of different kinds of fruits. Picking out different kinds of fruits is a routine task in supermarkets, where the seller must identify not only the species of a particular fruit (i.e. orange, banana, apple, grapes), but also its variety to determine its price. It is the hardest task for the seller to put the fruit which will be right from the inside and should be tasting good as well .This problem has been addressed by packaging fruits, but most of the time consumers want to pick the right fruit themselves, which cannot be packaged, and which must be weighed.

In this paper we have propose a new dataset of images containing popular fruits. The dataset was named Fruits360 and it can be downloaded from the address pointed by reference [8]. Fruits have always occupied an important place in human nutrition, due to the properties they offer, the amount of supply and the easy purchase of the product. Currently, the processes of selection of harvested fruits that are available for sale require expert inspections or complex systems, procedures that are high in cost and should have controlled environments. In the best cases, the selected fruits are in the biologically mature. Here classification processes of the degree of maturity of fruits require the use of complex systems, which, most of the times, are not within the reach to consumers who don't have clear view in knowledge of the characteristics that a fruit must have in order to be categories as the maturity of fruit, the shape fruit, the fuzziness of fruit, or the fruit is rotten. In this paper we have describes the use of a convolutional neural network using VGG16 model for the detection of estimated accuracy of the following fruits.

Related work

In this section we review several previous attempts of detection of fruit ripeness using digital image processing. In [1] article authors discussed different fruit ripening agents along with their ripening mechanisms and possible health hazard. It is important to check chemical criteria, mechanisms, effects on fruit quality and nutrition value.Where they found Ethylene is the major ripening agent produced in natural way within the fruits to instigate ripening process. Artificial fruit ripening is a complex issue especially in developing within countries Therefore here we have consider fruits which are ripping or yet to be ripped, so that the buyers can have all organically ripped fruits without toxic chemical harming their body. The work authors investigate in [2[resulting for ripe or unripe fruits recognition was given. The applied procedure codes were build and run in MATLAB. The descriptions which are used on this work have changed things needy on the surface surroundings. The approach of the camera, the placement of the sun, the time accomplish the picture of fruit which can touch for collective or shrinking the percentage. But if the situation of the camera is transformed and engaged the image from another perspective, it might be potential to disclose each fruit without help.

The author in this article has evaluated a number of the machine vision techniques to classify selected citrus fruits supported color analysis using single view fruit images. Algorithms were developed to classify the chosen citrus fruits, like orange, sweet-lime, and lemon, supported single view fruit images and therefore the fruits were categorized into different classes supported external

parameters like color and maturity. the one view fruit images were analyzed to extract the hue and classify using methods like color distance, LDA(linear discriminant analysis), and PDF(probability distribution function).The results clearly indicate that either hue or hue and saturation are sufficient for color classification, whereas the use of saturation alone does no give satisfaction in results. For the colour distance method, both hue and saturation were used for color classification.

[4]Non destructive maturity detection of tomatoes is that the main objective of this work. this is often done using deep transfer learning, an emerging computer vision technique. Tomatoes were classified automatically into three classes of maturity-immature, partially mature and mature using this method. The Several CNN pre-trained models of transfer learning like VGG16, VGG19, Inception V3, ResNet101 and ResNet152 are used here for solving the targeted task of classification.where VGG19 gives 97.37% classification accuracy.Thus it's found that transfer learning could be a viable solution to image classification and may be adopted in food and agriculture for solving classification and recognition related problems economically and accurately. But Size grading of agricultural products is another important processing operation which will be automated using machine learning. Where size grading using machine learning may be a complex process, therefore, authors consider the task for future investigation.

The author, In [5] article proposed a general approach of developing to estimate the ripeness level without touching the fruit. The two methods is used for this purpose are - color image segmentation and mathematical logic technique. Four images of one fruit are clicked from four directions and separate desired part from each image using color image segmentation.This approach can operate directly on RGB color space without the necessity of color space transformation. Moreover, the system are often applied to different applications with none difficulty by merely changing the values of the parameters a, b and c This technique is accustomed detect ripeness level of fruits, vegetables with color bases.But in some cases the range do not give accuracy. Some value of RGB lies in overlapped regions in red, green and blue mean values. Hence sometimes provide unexpected results.

In [6] paper an affordable method of combination of image processing and artificial neural network (ANN) technique is used to predict cherry and strawberry color parameters they identified the pre-mature, early-mature, mature and over-mature fruits supported quality in image processing using MATLAB is successfully finished 63% accuracy in cherry fruit and 60% accuracy in strawberry fruit. By using the thresholding technique the cherries and strawberry at different stages of ripeness were segmented successfully.The colour measuring technique discussed during used MATLAB software here for image analysis has been used to provide a more adaptive way to measure the colour of the many fruits and the traditional expensive color-measuring instruments.Accuracy is only better of this system with low cost makes it more useful. But in other system with this accuracy is much less .

The authors introduced fusion approch in [7] which is validated using a multi-class fruit-and-vegetable categorization task in an exceedingly semi-controlled

environment, like a distribution center or the supermarket cashier. The results show that the answer is in a position to scale back the classification error in up to fifteen percentage points with respect to the baseline. It shows the multi-class classification as a collection of binary problems in such how one can assemble together diverse features and classifier approaches custom-tailored to parts of the matter.Whether or no more complex approaches like CCVs(color coherence vectors) ,BIC(border/interior)descriptors, appearance-based descriptors provides good results for the classifying continously cause an open problem. It will be unfair to conclude they are doing not help within the classification as long as, their success is very supported their patches representation. Such approaches are computational demanding and maybe not advisable in some scenarios it exampled for some few category of fruits only. By studying the above research papers we have seen that there are some limitations in each papers like finding chemicals involving in the process of fruit ripening which can be harmful for the human body, using slow processing tools and old methods, etc..So we have tried to solve and overcome some of the problems coming across and giving better version for detection of fruit ripeness in our project.

Methodology

CNN

A convolutional neural network (CNN) could be a style of artificial neural network used for image recognition and processing that's specifically designed to process pixel data. CNNs are powerful image processing, AI (AI) that use deep learning to perform both generative and descriptive tasks, often using machine vison that features image and video recognition, together with recommender systems and Natural Language processing (NLP). A CNN uses a system very like a multilayer perceptron that has been designed for reduced processing requirements. The layers of a CNN contains an input layer, an output layer and a hidden layer that has multiple convolutional layers, pooling layers, fully connected layers and normalization layers.

Image classification

Image classification using CNN forms a big a part of machine learning experiments. Together with using CNN and its induced capabilities, it's now widely used for a variety of applications-right from Facebook picture tagging to Amazon product recommendations and healthcare imagery to automatic cars. the explanation CNN is so popular is that it requires little pre-processing, meaning that it can read 2D images by applying filters that other conventional algorithms cannot. we are going to delve deeper into the method of how image classification using CNN works.

VGG16 model

In an annual computer vision competition is a challenge on the ImageNet large scale visual recognition Each year, teams compete on two tasks. the primary is to detect objects within an image coming from 200 classes, which is termed object localization. The second is to classify images, each labeled with one in every of

1000 categories, which is termed image classification. VGG 16 model won the first and 2nd place on the above categories in 2014 ILSVRC challenge. The VGG16 model achieves *92.7% top-5* test accuracy on this dataset which contains *14* million images belonging to 1000 classes.

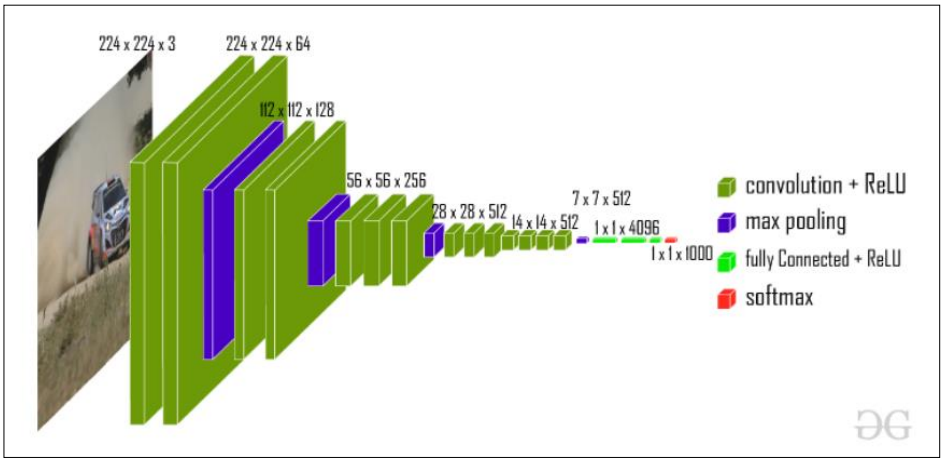


Figure 1. VGG16 Architecture [9]

The dataset contains images of fixed size of 224*224 and have RGB channels. So, we've got a tensor of (224, 224, 3) as our input. This CNN model process the input image and gives outputs as a vector of 1000 values. The following equation suggests the classification probability for the represented class. Suppose we've a model that predicts that image belongs to class 0 with probability 0.1, class 1 with probability 0.05, class 2 with probability 0.05, class 3 with probability 0.03, class 780 with probability 0.72, class 999 with probability 0.05 and every one other class with 0. as shown in equation (1) and (2)so, the classification vector for this may be:

$\hat{y}=[\hat{y}_0, \quad \hat{y}_1,\hat{y}_2 \quad ,\hat{y}_3\ldots\ldots\hat{y}_{999}]$ ……(1)

$\hat{y}=[\hat{y}_0=0.1 , \hat{y}_1=0.05, \hat{y}_2= 0.05, \hat{y}_3=0.03,\ldots\ldots\ldots\ldots,\hat{y}_{780}=0.72,\ldots\ldots\ldots\hat{y}_{999}=0.95]$ ……(2)

To make sure these probabilities add to *1*, here we use softmax function. This softmax function is defined as :

$$P(Y = j|\theta(i)) = e\theta^{(i)} \sum_{j=0}^{k} e^{\theta_k^{(i)}}$$

Where $\theta=W_0X_0+W_1X_1+\ldots.+W_KX_K=\sum_{j=0}^{k} w_i x_i = W_T\, x$

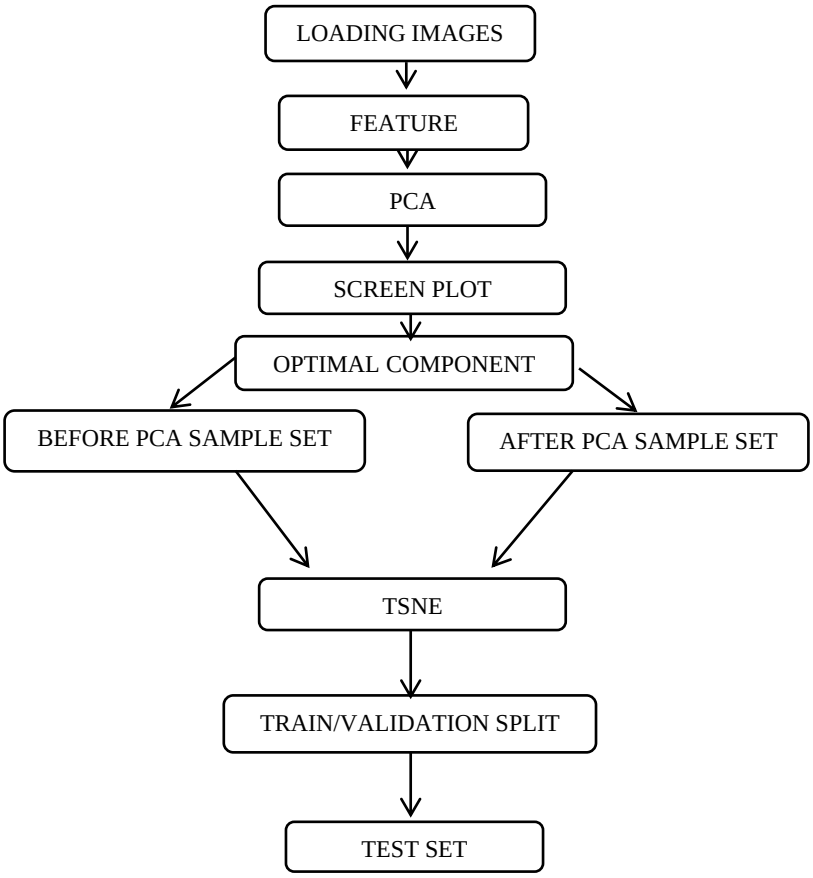
Hue Saturation Value (HSV) Feature

The Hue Saturation Value (HSV) represents the colour, dominance of color and brightness. Therefore, the colour detection algorithm are often accustomed search in terms of color position and color purity. The HSV accustomed detect the

pixels.The scale provides a numerical readout of your image that corresponds to the colour names contained therein. The Hue of HSV is measured in degrees from 0 to 360. as an example, cyan falls between 181–240 degrees, and magenta falls between 301–360 degrees. the worth and saturation of a color are both analyzed on a scale of 0 to 100%. Most digital color pickers are supported the HSV scale, and HSV color models are particularly useful for choosing precise colors for art, color swatches, and digital graphics.

Class detection

Class Detection for an image is a computer technology related to computer vision, image processing, and deep learning that deals with detecting instances of objects in images and videos. OpenCV is used as the huge open-source library for computer vision, machine learning, and image processing and now it plays a major role in real-time operation which is very important in today's systems. By using it, we can process images to identify different type of fruits.



Flowchart: Implementation of image classification in PYTHON

The above flowchart describes the process which is to be executed sequential firstly starting with loading an images to Unzip fruits and store image in train and test set respectively. Store training set x features as images. PCA(Principal

Components Analysis) reduce the dimentionality of this large dataset by transforming a large set of variables into a smaller one that still contains most of the information in the large set. By using PCA as a result, we are able to reduce our dataset to 50 components with 99.68% variance retained. Screen Plotting can be retained by a lot of variance in the used dataset with very few dimensions.

```
components       50.000000
explained_var     0.002001
shifted_var       0.001964
difference        0.000037
Name: 4, dtype: float64


PCA with optimal number of components (50)
```

Figure 2. 50 components is the optimal number of components to use for this dataset. It retain 99.68% (1-.000037) variance with just 50 components

In order to grasp whether PCA are useful or not, we'd like to make a screen plot. A screen plot shows the amount of components plotted against explained variance. we would like to use PCA if a low number of components includes a high cumulative explained variance. The plot below shows that using PCA is helpful, and as a result, we are ready to reduce our dataset to 50 components with 99.68% variance retained as shown in fig(2).

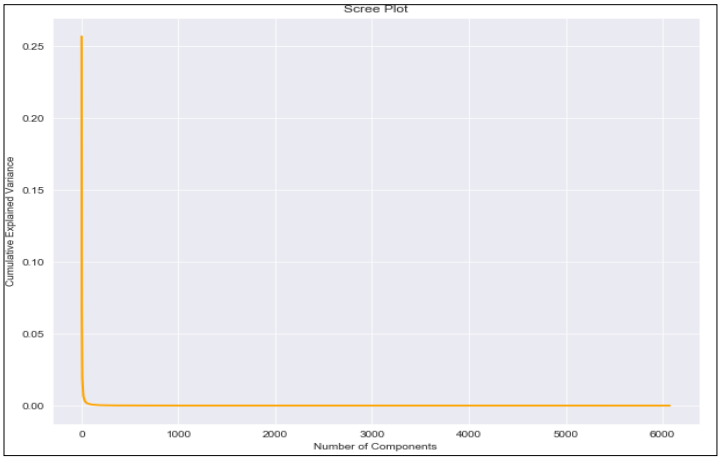


Figure 3. This screen plot shows retained variance in the given dataset with very few dimensions

Here below images fig(4) & fig(5) show that the pictures are rather more blurred and undefinable. This can be because these images only have 50 components each, rather than 30,000. Although identifying the fruits during this plot is difficult for the human eye, our PCA model identifies these fruits nearly the identical as if they were untouched this can be the wonder of PCA.

Figure 4. Before PCA (untouched)

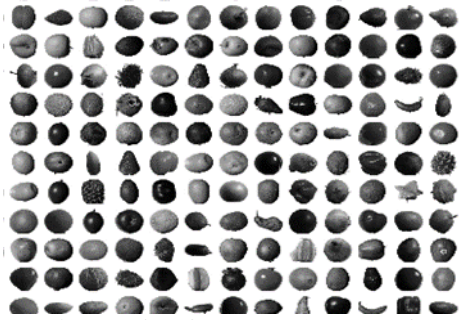


Figure 5. After PCA (grayscale)

Table 1
TSNE output shows 50 components from PCA as 2 components x and y

	x	y	label
0	1.038440	-1.045200	Apple Crimson
1	0.936067	-1.099165	Apple Crimson
2	0.936550	-1.099763	Apple Crimson
3	0.937179	-1.100508	Apple Crimson
4	0.937651	-1.101029	Apple Crimson

Above table table(1) shows that after getting PCA sample set further moving to the process of t-distributed Stochastic Neighbor Embedding(TSNE) it reduce dimension non-linear way which allowed to represent all our 50 PCA components we obtained, in 2 dimensions. TSNE is similar to dimension reduction technique like PCA, but in this case, we used TSNE for visual purposes. The fruits are still clustered together even after reduced to 50 components as shown in fig.(6) below.

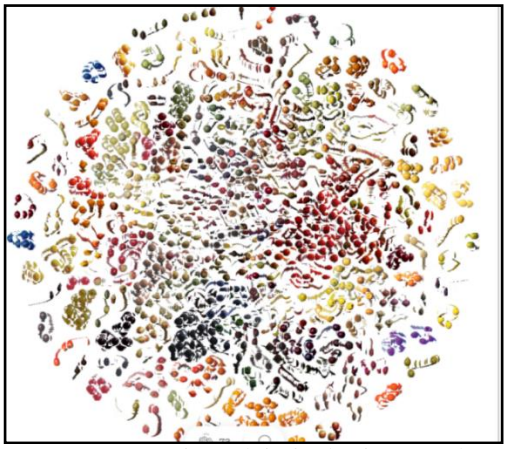


Figure 6. TSNE plot with fruit dataset images

Result

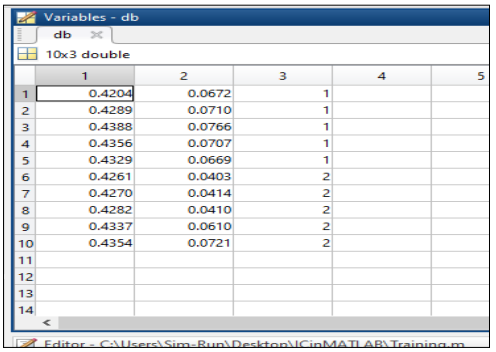
Dataset review

Dataset has been taken from pointed to reference [8] fruit-360.There are various type of fruit in the dataset Apple, Avacado, Banana, Pear etc.The total number of images is90483. Training set contain 67692 images (same fruit of different varieties like apple braeburn , apple crimson are stored as per their belonging to different classes).Test set size contain 22688 images The number of classes are131 (fruits and vegetables, here we used only fruits). And the image size is 100x100 pixels.As the dataset if captured from Logitech C920 web camera by the author of Fruit360 it is a 2012 model which is sharp, clear, wide field in view but having some bugs in it.There are some other better camera or webcam are in market which is best in quality for pictures and videos.Better the quality of dataset better will be the estimation accuracy for detection of fruit ripeness. Here we have divided the dataset into two parts for fruits, one is training dataset and another is test dataset.

Experiments

For the experiment obtaining accurracy greater than other softwares here we have shortlisted two fruit Apple and Blueberry from the taken Dataset. This given database can be primarily classified with the help of a working MATLAB program. In order to enhance our outcomes as precise as possible in terms of a code that can differentiate the data in terms of image classification in a given datasets, In Matlab first make a folder consisting of different type of images,feature statiscal.m,training.m ,testImage.m file. Copy the link of the folder and open in MATLAB and on the training.m file into the EDITOR window in MATLAB. RUN the training.m file choose the image from the folder for classification used two fruits Apple and Blueberry. Saving the image of all Apples in class 1 and Blueberries in class 2 we classified two different type of images a databases for apple and blueberry as shown in table (2).Hence, it will be generated as a result of it will detect class as per we select the inputed image from the generated database shown in fig.(7).

Table 2
Database created while processing sets Matlab



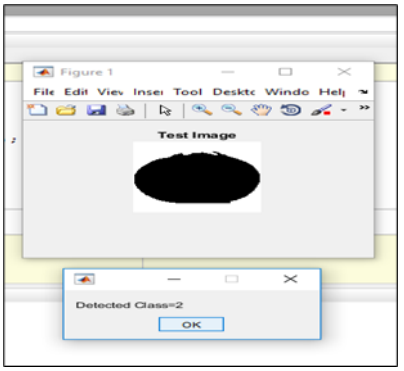


Figure 7. Grayscale image and Detected Class for selection image

But this is very slow and manual process where large dataset requires more time and some manpower for selection sets to obtain required classes. Therefore, we have used a working Python program, which comes with more efficient and precise output as desired.

Result and Discussion

Here we used VGG-16 CNN model which was one of the best performing architecture in ILSVRC challenge 2014.It was the runner up in classification task with top-5 classification error of *7.32%*. It is also best for localization task with *25.32%* localization error.VGG16 is object classification and detection algorithm with greater in size i.e 528MB which is able to classify more than 1000 images of 1000 different catagories. VGG16 is also outperforms baselines on many tasks and dataset outside of ImageNet as it has 16 layers to support object recognition model. The project resulting accuracy 92.7% for used dataset. Here for this whole detection process we can use VGG19 model as well which have additional three convolutional layers i.e. extra 21MB size. Here we have taken VGG16 convolutional neural network model because it was sufficient for processing of our dataset. Apart from the dataset to see if it work for some other images we have taken some other fruit images estimated by VGG16 algorithm

(peaches fig.(8) and pomogranates fig.(9))as well to show that accuracy of ripeness of train set fruits we are getting shown in fig.(10) and (11) .

Figure 8. Train set image of peaches.

Figure 9. Train set image of pomogranates.

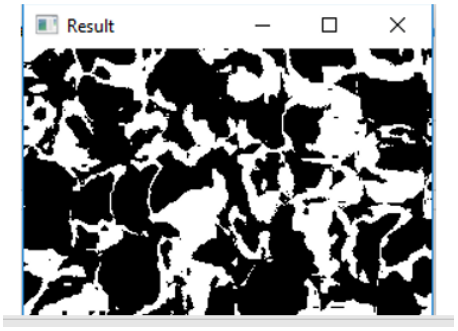


Figure 10. Tested set image of peaches

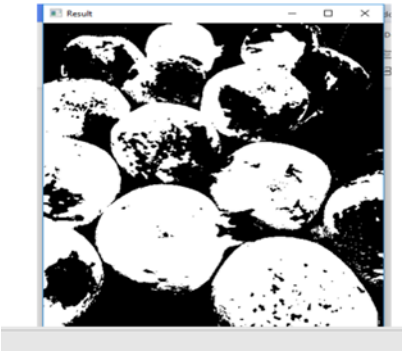


Figure 11. Test set image of pomogranate

Conclusion

For a long period of time, it has been observed that in the research community there is the circulation on researches for fruit recognition on fruit-360 dataset which consist almost type of fruits. Over a period with consistent studies on this paradigm, higher accuracy has been achieved in the results of the studies, whereas same result has been achieved through the project. Here, in our study we reflect a working platform with higher accuracy & bigger datasets in relation to other CNN models, As an outcome of this we are using VGG16 model here its inference time is quite good. VGG-16 contains large number of layers will have higher test error and generalize lesser.The motive of project is to concentrate on reducing human effort and making human life easier for finding best fitted fruit for their healthy diet. Fruit ripeness detection will be able to reduce the current ongoing problems. It reduces confusion among the particular fruit whether it is raw, ripped or yet to ripped. As the above conclusion suggests, there is always a possibility for enhancement in this domain. But, as of current conclusions our proposed method outperforms all of the previous studies.

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