

## **FRUIT IDENTIFICATION AND CLASSIFICATION USING MACHINE LEARNING**

**Abstract--**At supermarkets, the most important factor in selecting fresh fruits is fruit identity and quality indication. We can't inspect every fruit since it would take too much time and effort, and we always want to buy the freshest fruits when we go shopping. Fruits can get harmed, rotting, and impacted by their environment. With the aid of image processing and machine learning, we are able to recognize fruits and classify them on the different classes, making it simple for anyone to choose the fresh fruit available. In this project, we offer a useful technique for classifying fruits and indicating them. The types of fruits are determined using image processing and machine learning techniques. One of the fascinating uses of computer vision for both commercial and agricultural applications is the recognition and classification of fruits using deep learning. Nonetheless, because to the similarities in color, shape, and size of fruits, researchers continue to have difficulty classifying them. By creating a technique for the identification and classification of fruits, this effort aims to address some of the difficulties encountered by the earlier researchers.

**Keywords:** Machine Learning, Fruit Identification, Image Processing.

### **1. INTRODUCTION**

Fruit identification entails distinguishing between several fruit varieties based on their shape, size, and other attributes. This process is vital for ensuring that fruits are accurately labeled and marketed, and for ensuring that consumers receive the desired product. On the other hand, quality indication entails determining the overall quality of fruits based on a variety of elements, including appearance, texture, taste, and chemical indicators. This technique is vital for ensuring that fruits satisfy market criteria for freshness, ripeness, and overall quality. Accurate quality assessment can also help to identify any defects or issues that may affect the marketability or profitability of the fruit crop.

In recent years, technological advancements in spectroscopy, imaging, and other non-destructive methods have provided new tools for more accurate and efficient fruit identification and quality indication. These methods can help to reduce waste, increase efficiency, and improve overall fruit quality. Fruit identification and categorization are significant activities in the domains of horticulture, agriculture, and botany. It's crucial to correctly identify and categorize various fruit

varieties for a number of reasons, including comprehending their distinctive traits, figuring out their market value, and informing breeding operations. Fruit identification entails identifying various fruit varieties based on their external and internal traits, such as size, shape, color, texture, and taste. This procedure is crucial to ensuring that fruits are properly marketed and labeled, as well as that customers receive the desired product. Accurate identification can also help to stop misidentification and the spread of invasive species. Computers can now recognize and categorize the items seen in films or photographs with the aid of deep learning algorithms. When a neural network in its early stages of development was able to categorize the object based on edge detection, the field of computer vision was first established in the 1950s. The availability of a wealth of information made possible by the advent of the internet hastened the advancement of this profession.

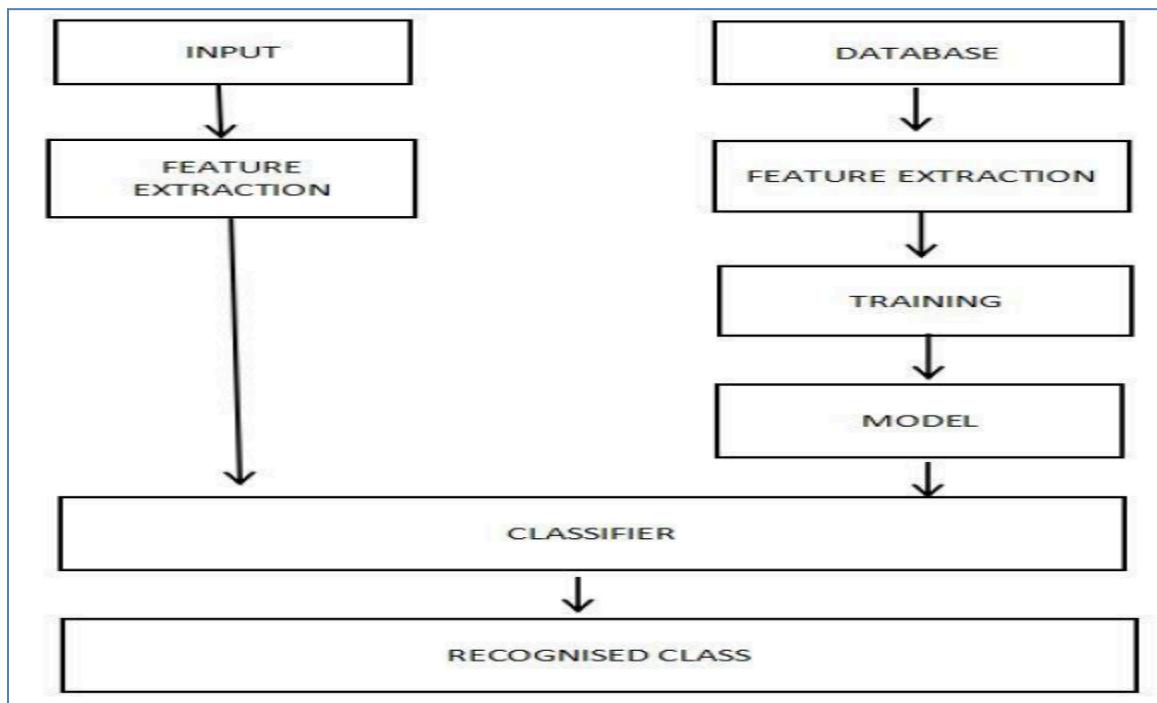


Figure 1: Proposed System Design

The proposed fruit identification and classification system will use computer vision and machine learning techniques to accurately identify and classify different types of fruits based on their external attributes such as color, texture, and shape. The system will comprise of the following components:

- █ the system will use cameras or other imaging devices to take pictures of or record videos of fruits.

- Pre-processing: In order to enhance the quality of the images or videos and the precision of the analysis that follows, pre-processing is applied to them.
- Fruit classification: The system will examine the photos or videos and determine the type of fruit using machine learning techniques like computer vision and deep learning.
- Fruit Classification: Based on their outward characteristics, such as colour, texture, and shape, the algorithm will further categorise the identified fruits. The system will use feature extraction and classification techniques to group the fruits into different categories.
- Data Integration: The system will integrate data from sensors and other sources to provide a comprehensive view of fruit quality.
- Output: The system will provide real-time output in the form of visual or audio feedback, enabling farmers, distributors, and retailers to make informed decisions about the types of fruits they are dealing with.

The enormous amount of data created each day has significantly increased these systems' accuracy in just over a decade. The demand for goods is rising across all industries, which has led to an increase in automation, which in turn has increased the usage of computer vision and its applications. Every industry that relies on machines to analyse films, photos, etc. can clearly see the impact of this technology. By tackling the complications, computer vision seeks to improve efficiency while overcoming the limitations of the conventional system. Although computer vision is utilized in many other applications, this study focuses on several deep learning algorithms for classifying fruits.

## 2. LITERATURE REVIEW

External appearance It has been determined that a fruit's external look plays a significant role in determining its quality. For instance, research have revealed that external flaws like blemishes, bruising, or other flaws can drastically lower the market value of fruits (Gonzalez et al., 2018). Additionally, certain fruit varieties have distinctive exterior traits that can be used to identify them, such as the fruit's size, shape, and colour (Dhiman et al., 2020). Fruits have been found to have a variety of textures, which is another key quality indicator. According to studies, the firmness of fruits can be used to determine their level of maturity, with stiffer fruits typically being less ripe (Knoerzer et al., 2020). Similar to how soft spots or deterioration might point to subpar quality and decreased market value (Garcia-Sanchez et al., 2017). Chemical indicators

several chemical parameters, such as brix level, acidity, and pH level, have been employed to evaluate fruit quality. Indicators of fruit quality and ripeness, such as brix level, which quantifies the fruit's sugar content, have been identified (Wang et al., 2020). Furthermore, research has revealed that it is possible to evaluate the freshness and quality of fruits based on their pH and acidity levels (Singh et al., 2019).

Non-destructive techniques Non-destructive techniques like imaging and spectroscopy have been utilized more and more to identify and rate fruit quality. For instance, studies have demonstrated that near-infrared spectroscopy may be used to precisely assess the sugar content of fruits, which is a major sign of their quality (Xie et al., 2021). Similar to this, imaging methods like hyper spectral imaging have been applied to determine fruit maturity and detect surface flaws (Li et al., 2019). The literature as a whole emphasizes the value of carefully evaluating many aspects, such as appearance, texture, and chemical indications to precisely identify and assess the quality of fruits. Moreover, non-destructive techniques like imaging and spectroscopy can be used to do fruit quality assessments that are more precise and effective.

### **3. METHODOLOGY**

The framework uses a camera to take a picture of the fruit, and the first phase uses a small neural network in Tensor Flow to determine whether the image is of a natural product. The TensorFlow CNN neural system learning on a Linux server is then given the image to perform further grouping.

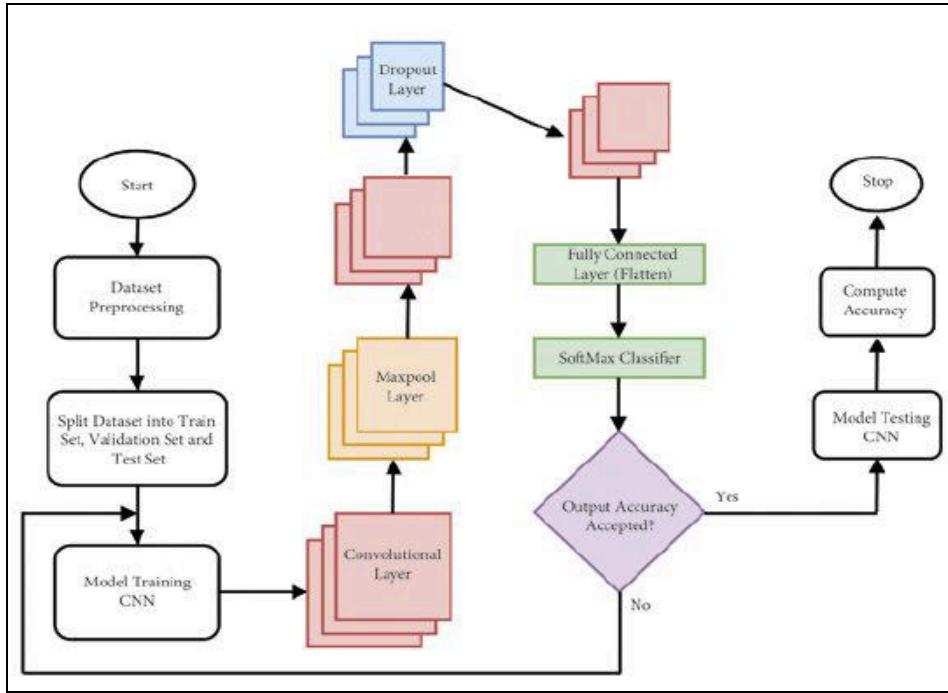


Figure 2: Tensor Flow CNN neural system learning

The Google-provided Tensor Flow code modifies the union, pooling, and arranging configuration of the Inception-v3 model to coordinate the number of classes and classes of pixels in the image with minor changes to the last layer. Between the info and yield layers, in the concealed layer of CNN, there is a convolution layer and a pooling layer.

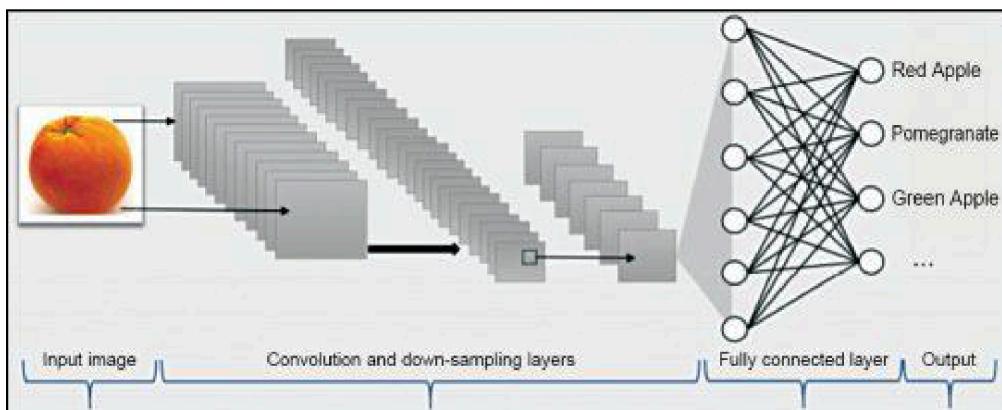


Figure 3: concealed layer of CNN, there is a convolution layer and a pooling layer

The method for bringing down or testing the picture's objectives is repeated in these two tiers. A portion of the information image that can be relevant for grouping is given a weighted channel by the convolution layer, creating an element map. By sub-testing the most important portion of the component map that it acquired from the convolution layer, the pooling layer reduces the

element map. It decreases the size of the information while maintaining the qualities, preventing the difference in the information caused by the area change and enhancing the neural system's display by doing so. The categorization is done with these deleted highlights in mind.

## Deep Learning

A Wing of ML called "deep learning" is totally supported by ANN. Deep learning may be thought of as a form of mimic of the human brain because neural networks are made to resemble it. With deep learning, not everything needs to be explicitly programmed. DL is not a fresh idea. It's there in existence from some time. Because we did not have as much data and processing power back then, it's more common now. 14 million photos may be accessed by Image Net, a well-known deep learning tool for image recognition, in its dataset driven algorithms. For deep learning algorithms that use photos as their training dataset.

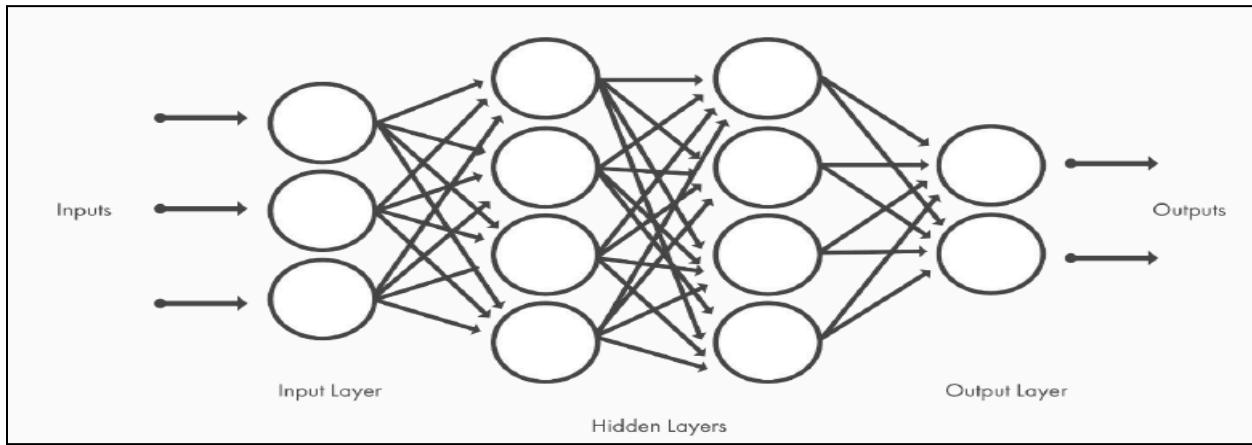


Figure 4: deep learning algorithms that use photos as their training dataset

### CNN

CNNs, a kind of Deep Neural Network, are often used for image analysis and are effective at recognizing and categorizing certain characteristics in images. Image classification, image analysis for medical use, picture and video recognition, computer vision, and natural language processing are some of its uses. CNN is beneficial for picture recognition because of its high degree of accuracy. Several industries, including phone, security, and medical image analysis, and recommendation systems, use image recognition.

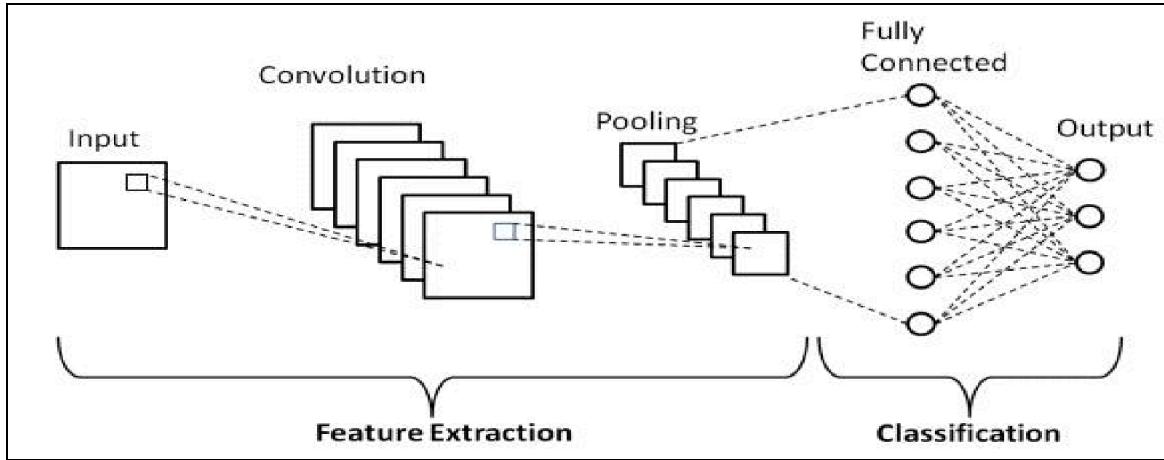


Figure 5: Convolution Layer

## 4. IMPLEMENTATION

### 4.1 Database Setup

We used fruits 360 data baseset from Kaggle which contains Apples (different varieties: Golden, Golden-Red, Granny Smith, Red, Red Delicious), Apricot, Avocado, Avocado ripe, Banana (Yellow, Red), Cactus fruit, Cantaloupe (2 varieties), Carambula, Cherry (different varieties, Rainier), Clementine, Cocos, Dates, Granadilla, Grape (Pink, White, White2), Grapefruit (Pink, White), Guava, Huckleberry, Kiwi, Kaki, Kumquats, Lemon (normal, Meyer), Lime, Litchi, Mandarine, Mango, Maracuja, Melon Piel de Sapo, Mulberry, Nectarine, Orange, Papaya, Passion fruit, Peach, Pepino, Pear (different varieties, Abate, Monster, Williams), Physalis (normal, with Husk), Pineapple (normal, Mini), Pitahaya Red, Plum, Pomegranate, Quince, Raspberry, Salak, Strawberry (normal, Wedge), Tamarillo, Tangelo.

### 4.2 Implementation steps

Implementation involves following steps:

1. Importing the required Libraries
2. Data loading
3. Labeling the data
4. Data Pre-processing
5. Visualizing the data with labels
6. Data Splitting
7. Building CNN Model

8. Traing model
9. Evaluating Model

#### 4.2. 1. Importing the required Libraries

We will need opencv, pandas, numpy, tensorflow, matplotlib, sklearn.

```
: import os
import cv2
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split
import tensorflow as tf
from tensorflow import keras
import seaborn as sns
from sklearn.metrics import confusion_matrix
from sklearn.metrics import classification_report
```

#### 4.2.2. Data loading

Here we have to load the data from the directory.

```
train='data/fruits-360/Training'
file_names=os.listdir(train)
pd.DataFrame(file_names,columns=['Names'])

Names
0    Apple Braeburn
1    Apple Golden 1
2    Apple Golden 2
3    Apple Golden 3
4    Apple Granny Smith
...
65      Salak
66    Strawberry
67  Strawberry Wedge
68      Tamarillo
69      Tangelo
70 rows × 1 columns
```

#### 4.2.3. Data Labeling

In this step since our data do not have labels we use the directory names as labels and indicate the all the class's images we loaded with the directory names.

```

train_image=[]
label=[]
for file in file_names:
    path=os.path.join(train,file)
    for img in os.listdir(path):
        image=cv2.imread(os.path.join(path,img))
        train_image.append(image)
        label.append(file)
pd.DataFrame(label,columns=['label'])

label
0   Apple Braeburn
1   Apple Braeburn
2   Apple Braeburn
3   Apple Braeburn
4   Apple Braeburn
...
35128     Tangelo
35129     Tangelo
35130     Tangelo
35131     Tangelo
35132     Tangelo
35133 rows x 1 columns

```

#### 4.2. 4. Data Pre-processing

Here we pre process the data with the images and the labels.

```

train_image=np.array(train_image)
label=np.array(label)

code={}
label_unique=list(pd.unique(label))
for i in range(70):
    code[label_unique[i]]=i
code

```

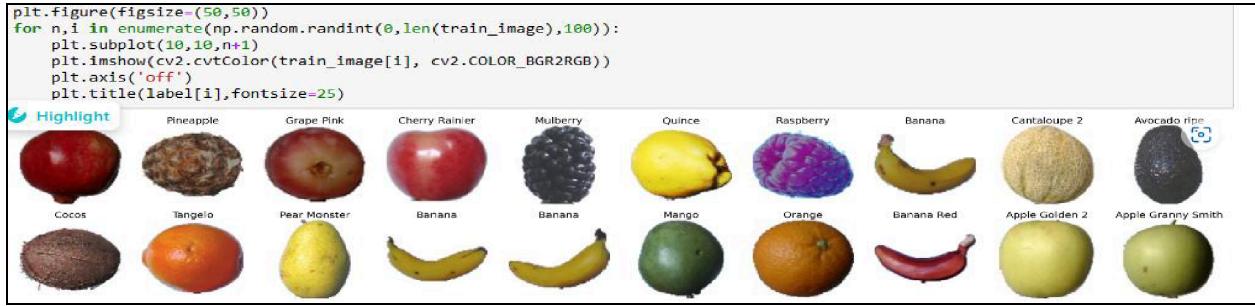
```

def get_Name(N):
    for x,y in code.items():
        if y==N:
            return x
label2=[]
for i in label:
    label2.append(code[i])
label2=np.array(label2)
pd.DataFrame(label2)

```

#### 4.2.5 Visualizing the Data with labels

Here we visualize the input data with the labels.



#### 4.2.6. Data splitting

Here we split the data for training and evaluation purpose.

```
x_train, x_test, y_train, y_test = train_test_split(train_image, label2, test_size=0.1, random_state=44, shuffle =True)
print('x_train shape is ', x_train.shape)
print('x_test shape is ', x_test.shape)
print('y_train shape is ', y_train.shape)
print('y_test shape is ', y_test.shape)

x_train shape is (31619, 100, 100, 3)
x_test shape is (3514, 100, 100, 3)
y_train shape is (31619,)
y_test shape is (3514,)
```

#### 4.2. 7 Building CNN Model

Here we build a Sequential model with keras, with class size of 131.

```
shape=(100,100,3)
num_class=131
model=keras.models.Sequential()
model.add(keras.layers.Conv2D(filters=32, kernel_size=(3,3),activation=tf.nn.relu,input_shape=shape))
model.add(keras.layers.BatchNormalization())
model.add(keras.layers.MaxPool2D((3,3)))
model.add(keras.layers.Dropout(.3))
model.add(keras.layers.Conv2D(filters=64, kernel_size=(3,3),activation=tf.nn.relu))
model.add(keras.layers.BatchNormalization())
model.add(keras.layers.MaxPool2D((3,3)))
model.add(keras.layers.Dropout(.3))
model.add(keras.layers.Conv2D(filters=128, kernel_size=(3,3),activation=tf.nn.relu))
model.add(keras.layers.BatchNormalization())
model.add(keras.layers.MaxPool2D((3,3)))
model.add(keras.layers.Dropout(.3))
model.add(keras.layers.Flatten())
model.add(keras.layers.Dense(512,activation=tf.nn.relu))
model.add(keras.layers.Dropout(.3))
model.add(keras.layers.Dense(128,activation=tf.nn.relu))
model.add(keras.layers.Dropout(.3))
model.add(keras.layers.Dense(num_class,activation=tf.nn.softmax))
```

#### 4.2.8 Training Model

In this step we compile the model with loss function as sparse categorical cross entropy. And train the model with training data and check the loss and accuracy of the model.

```
model.compile(optimizer = 'adam', loss='sparse_categorical_crossentropy',metrics=['accuracy'])

hist=model.fit(X_train,y_train,epochs=5)

Epoch 1/5
989/989 [=====] - 322s 326ms/step - loss: 0.2766 - accuracy: 0.9076
Epoch 2/5
989/989 [=====] - 318s 322ms/step - loss: 0.1779 - accuracy: 0.9403
Epoch 3/5
989/989 [=====] - 317s 320ms/step - loss: 0.1357 - accuracy: 0.9541
Epoch 4/5
989/989 [=====] - 317s 321ms/step - loss: 0.1274 - accuracy: 0.9587
Epoch 5/5
989/989 [=====] - 320s 324ms/step - loss: 0.1185 - accuracy: 0.9611
```

```
: hist_=pd.DataFrame(hist.history)
hist_
```

```
:      loss  accuracy
: 0  0.276647  0.907556
: 1  0.177926  0.940289
: 2  0.135715  0.954110
: 3  0.127411  0.958664
: 4  0.118538  0.961099
```

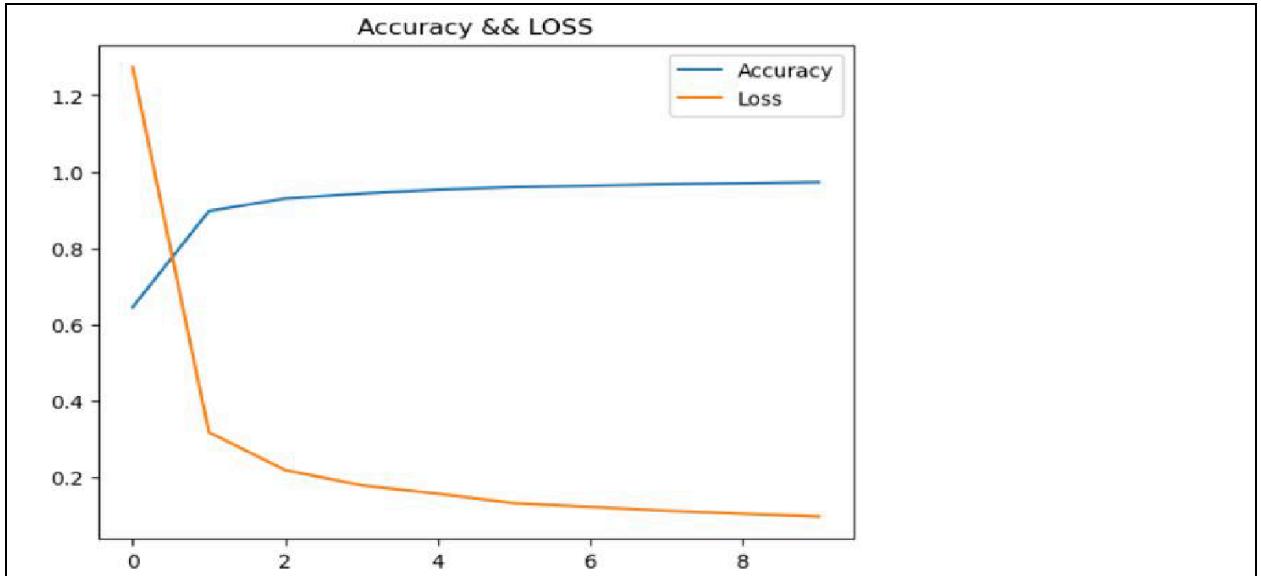
#### 4.2.9 Evaluating model

After training the model with training data we now evaluate the trained model with the evaluation data and check the loss and accuracy of the evaluation.

```
score, acc = model.evaluate(X_test, y_test)
print('Test Loss =', score)
print('Test Accuracy =', acc)

110/110 [=====] - 9s 75ms/step - loss: 0.4477 - accuracy: 0.9385
Test Loss = 0.4477287828922272
Test Accuracy = 0.9385315775871277
```

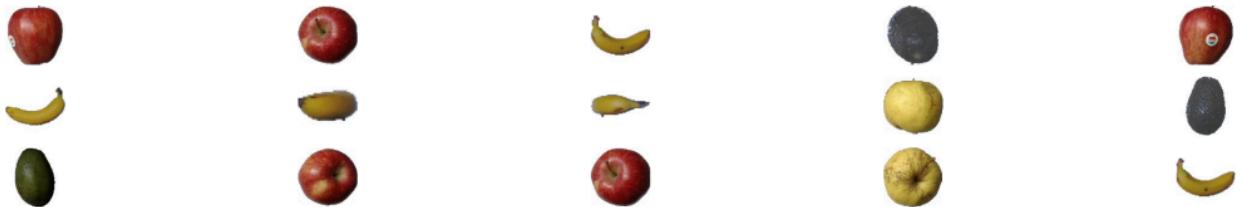
## 5. RESULTS AND ANALYSIS



This graph represent the loss and accuracy of the model we prepared. Loss can be seen as a distance between the true values of the problem and the values predicted by the model. Greater the loss is, more huge is the errors you made on the data.

This is some of the data we have for testing visualized below.

```
plt.figure(figsize=(100,100))
n=1
for i in range(15):
    plt.subplot(20,5,n)
    plt.imshow(cv2.cvtColor(X_test[i], cv2.COLOR_BGR2RGB))
    plt.axis('off')
    n+=1
```



In this step we input the model with the test data set we have prepared.

```
y_pred=model.predict(X_test)
y_pred
110/110 [=====] - 8s 71ms/step
array([[2.8618351e-17, 2.8970579e-34, 6.6088787e-27, ..., 8.0366358e-31,
       3.2923751e-21, 2.6017429e-28],
       [9.7316791e-16, 7.9403722e-01, 1.0950502e-10, ..., 3.0835635e-18,
       3.6886296e-17, 1.5043847e-20],
       [9.2267943e-28, 4.3883767e-28, 1.3878387e-22, ..., 6.5784575e-23,
       9.1823050e-21, 3.8175409e-24],
       ...,
       [1.2580797e-17, 2.1756892e-19, 5.6350622e-29, ..., 5.8043360e-24,
       8.6107602e-20, 2.5458880e-21],
       [2.3388514e-20, 2.6739471e-09, 3.4058732e-12, ..., 8.6563525e-17,
       8.0822657e-14, 5.4019760e-20],
       [1.2712874e-19, 5.2954378e-18, 5.9624064e-20, ..., 4.8833500e-21,
       2.4230241e-17, 3.6571309e-18]], dtype=float32)
```

And labeled the data with the respective labels.

```
pred_Name=[]
pred_number=[]
for row in y_pred:
    N=np.argmax(row)
    pred_Name.append(get_Name(N))
    pred_number.append(N)
pd.DataFrame(pred_Name,columns=['pred Names'])

pred Names
0      Apricot
1  Apple Golden 1
2  Melon Piel de Sapo
3      Cantaloupe 2
4      Tamarillo
...
3509      Apricot
3510      Lemon
3511   Mandarine
3512      Cantaloupe 2
3513      Kiwi
3514 rows x 1 columns
```

Here we tried to select an image from the test data set and print it with predicted label

```
plt.figure(figsize=(3,3))
input_num=9
plt.imshow(cv2.cvtColor(X_test[input_num], cv2.COLOR_BGR2RGB))
ti='Prediction: '+pred_Name[input_num]+'\n Freshness:'
freshness='100%'
result=ti.find('bruised')
if result>0: freshness= '50%'
result=ti.find('ripe')
if result>0: freshness= '10%'
plt.axis('off')
plt.title(ti+freshness,fontsize=20)

Text(0.5, 1.0, ' Prediction: Avocado ripe\n Freshness:10%')
```

**Prediction: Avocado ripe  
Freshness:10%**



Output no 2

**Prediction: Apple red fresh  
Freshness:100%**



Output no 3

Prediction: Apple Golden bruised  
Freshness:50%



## 6. CONCLUSION

The classification and identification of fruits is a critical undertaking in the agricultural, food processing, and retail sectors. Fruits should be properly identified and categorized to assist assure consumer satisfaction, quality control, and food safety. With the development of technology, a variety of procedures and techniques, including optical inspection, chemical analysis, molecular analysis, texture analysis, and AI/ML algorithms, are now accessible for the identification and classification of fruits. These techniques can be employed singly or in tandem to provide precise and effective outcomes. Modern methods and technology for fruit categorization and identification can greatly increase the accuracy and efficiency of this task. Accurate fruit identification and categorization are crucial for guaranteeing consumer safety and satisfaction given the rising demand for high-quality and safe food items. We can keep raising the caliber and security of the food we eat by developing and improving these techniques.

## 7. REFERENCES

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