1. INTRODUCTION

Image classification is the process of labelling and classifying groups of vectors and pixels in an image under certain specific rules. The efficiency of classifying images have been improved by computer vision approaches basically focusing on machine learning and deep learning approaches. Detection of defective or the rotten fruits is one of the major problems of the agricultural sector. It can cause major impact on the productivity if not classified correctly and at early stage. Rotten fruits if kept longer can also effect other fresh fruits.

The classification of fresh and rotten fruits is traditionally performed by hard working men which consumes lots of time and effort and sometimes the hard work is not even effective. Hence it increases manufacturing time and cost of a fruit product.

Hence for the purpose of minimizing human efforts, cost of producing fruit products and time, we came with the project that classify fresh and rotten fruits that uses computer vision techniques.

In this project we have used deep learning models to classify the fresh and rotten fruits.

Hence for feature extraction from an input image from the dataset consisting of various distinct fresh and rotten fruits we proposed a CNN model. We used a Softmax classifier on the images for classification purpose. We compared the accuracy rate for our model by using various models such as Xception, VGG16, VGG19 and MobileNet transfer learning.

After the image data is converted to greyscale we have used various segmentation techniques such as color based segmentation, marker based and edge detection techniques. Before the image data is passed for training it is present in the form of raw RGB format. Hence it is first converted into greyscale and then by thresholding and binarization, it is masked and we obtained masked binary image which is further trained using the deep learning methods. The purpose of this method is to classify the images of fruits based on their freshness, whether the fruits are fresh or rotten.

2. LITERATURE SURVEY

In this paper we have used deep learning techniques to classify the fruits based on their freshness. To classify fruits based on their freshness we found out that convolutional neural network performs best and provides best classification among other classification algorithms.

2.1. RELATED WORKS:

Sannakki et al., 2011 applied a hybrid smart method to detect the disease of a pomegranate fruit on the basis of ML and image pre-processing technologies. Similar to other modules, the proposed approach can be operated on four phases: Initially, the first image can be taken using a camera and then employed few pre processing frameworks like improvement, noise elimination, reshaping, extraction. Segmentation, morphological task, and so on. Furthermore, the color, shape, texture features are obtained and then the attained features were induced as the input to diverse MI. methodologies namely, ANN, SVM, FL, clustering, Genetic Algorithm (GA) and DT learning [4].

Malik et al., 2016 has initiated a robotic model for recognition, segmentation, and evaluation of fruits. The approach includes pre-processing, blob detection phases, K-means clustering, shadow reduction, and object separation. Gómez-Sanchis. 2008 has acquired an approach from computer vision domain. This approach enhanced opposing result formed by the nature of sphere-shaped things at image acquisition stage. In Omid et al., 2010, the researchers expected a method to determine the volume and mass of four various citrus fruits which includes: limes, lemons, oranges, and tangerines. The method employs the basic frustums to measure the mass and amount of the fruit [3].

Pydipati et al., 2004 has obtained a ML method for citrus diseases classification. It has used colour co-occurrence algorithm for classification. In this method, four feature extraction techniques are planned which include thirty-nine texture feature sets. These features are more classified into two techniques: NN and 48 RBF models. As per the outcome, the enhanced performance of accuracy rates up To 95% was traced [5].

Jhuria et al., 2013 has obtained on the detection of grapes and apple plant diseases. For instance, K-means model has been used for ANN classification method while segmentation is utilized to classify the feature extraction. On the other side, the weight of a mango plant can be estimated by using BP technique. The morphology, texture and color features were estimated to process the classification process. Shaikh et al., 2018 has employed few effective methodologies like K-means clustering, color and texture investigation in predicting the plant leaf diseases. In order to find and categorize diverse agricultures, the color and texture feature extraction are computed and shown in the normal and abnormal regions. It has been deployed with three classifiers such as PC classifier. K-means clustering and Bayes [6].

Sannakki et al., 2013 deployed an approach to classify the disease of a grape leaf under the application of AI and image preprocessing models. At the initial stage, every input image was gathered and some pre-processing modules namely, noise avoidance and thresholding take place. K-means method has been applied for image segmentation. The texture features are calculated by employing GLCM and lastly, BPNN classification can be applied for classifying process [12].

Harini and Bhaskari, 2011 has introduced a model to detect the lesion of a tomato leaf according to the computational objectives. In addition, the features are I related with healthy leaf features to examine the disease, Chen et al., 2010 has deployed a technique to identify the disease of corn plant using geometric, color and shape features under the application of NN as well as discrimination analysis. Then, it applied the morphological and 28 color features for examination purposes. Ullagaddi and Raju, 2017 has compared two models like PCA and Wavelets, Initially, PCA can be employed to extract Eigenvectors and dimensionality elimination [7].

Blasco et al. 2007 has differentiated amongst eleven different kinds of exterior defects of oranges and mandarins through a multispectral system, consisting of color, NIR and UV camera. By the use of various models in an individual way, the outcome is minimum in case of integration, as various defects can be identified by the use of cameras [8].

Al Bashish et al., 2010). Dubey et al., 2012 has deployed a model to predict the disease of an apple fruit by applying Local Binary Patterns (LBP). Therefore, the deployed approach is concatenated using 3 major modules such as, K-means clustering which is used in segmentation task, feature extraction and undergoes classification using multi-class SVM model [11].

Pujari et al., 2013 introduced a model for automated grading as well as identification of fungal infection of fruits using segmentation approaches on pomegranate, mango, and grape. It has been implemented in 2 levels initially, segmentation techniques like K-means clustering, watershed, region development (Ma et al., 2017) and Otsu thresholding is applied to detect normal and abnormali [9].

Meunkaewjinda et al., 2008 projected a classifying process for forecasting the disease of grape leaves. This system is operated with 3 stages: initially, color segmentation (Zhihua et al., 2013) has been processed on grape leaves for extracting the difficult background Secondly, grape leaves disease would be divided and finally, grape leaf diseases are recognised. In this study, BPNN and self-organizing features are employed to find the color of a grape leaf. In addition, GA as well as MSOFM (Hytla and Patrick, 2016) methodologies are used for the segmentation grape leaves whereas SVM classifier is utilized for classification. Process. At last, the segmented Images are extracted with the help of Gabor wavelet (Mousavi et al., 2016) method and further employed with SVM model for encountering the types of grape leaf lesions. Then, it is used on the grape leaves lesions into three groups like rust lesion, scab disease, and no trait [10].

2.2. MACHINE LEARNING

Machine Learning is the sector of look at that offers computer systems the functionality to examine without being explicitly programmed. ML is one of the maximum interesting technology that one could have ever come across. Machine learning is actively getting used today, possibly in lots of extra locations than one could expect.

In machine learning, training data is made available as an input to machine learning algorithms. Then kind of unknown data is passed to the classifier for testing purpose and then the classifier test the unknown data based on the experience of training data and make predictions. There are basically four types of ML approaches as described in fig 1 that is supervised learning, semi-supervised learning, unsupervised learning and reinforcement learning.
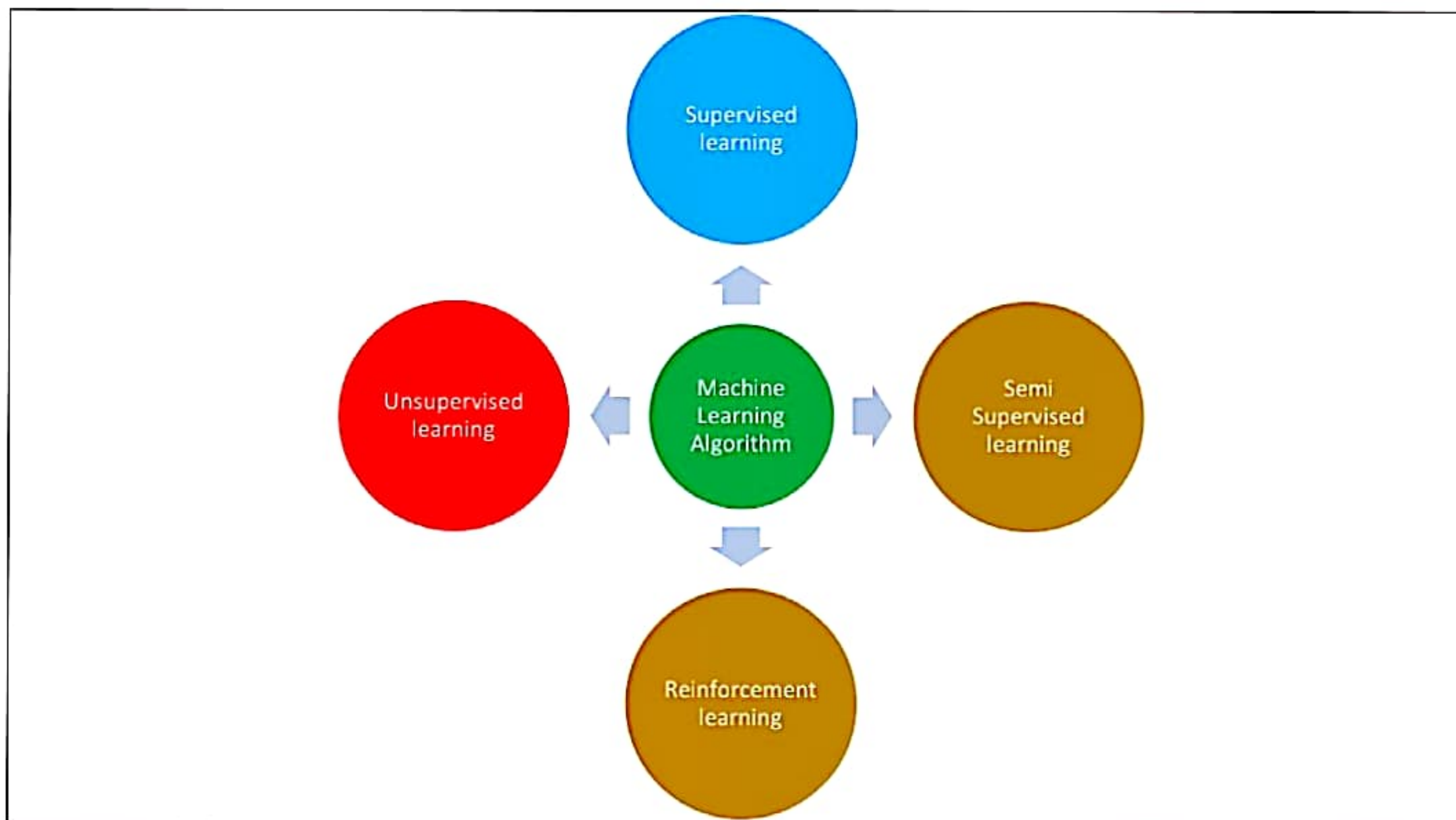

Fig1: Machine Learning Approaches

Supervised learning is best suited for regression and classification problems. In supervised learning the dataset basically consist of known inputs and known outputs. The intention of supervised learning to know is to make experience of facts inside the context of a question [20].

Unsupervised learning is an approach of machine learning where we only have the inputs in the dataset and based on the various analysis and trends within the dataset, the predictions are made. In this type of approach, trends itself discover the hidden styles and insights from the given statistics. It cannot be without delay implemented to a regression or class trouble due to the fact not like supervised getting to know, we've the enter statistics however no corresponding output statistics. The intention of unsupervised getting to know is to discover the underlying shape of dataset, and constitute that dataset in a compressed format. Problems such as dimensionality reduction, clustering and association are basically dealt by using unsupervised learning approach.

Data samples are categorized into four types for classification: false negatives (FN), true negatives (TN), true positives (TP), and false positives (FP). Classification accuracy (CA) is the most frequently used performance evaluation metrics for classification problems. This metric describes overall how accurate a model is when categorizing a data samples into the right class [24].

$$CA = \frac{TN+TP}{TN+TP+FN+FP} \qquad (1)$$

Recall is a metric that evaluates a model how good it is to predict relevant data points given the labels.

$$RECALL = \frac{TP}{TP+FN} \qquad (2)$$

Precision describes how precise a model is to select positive/relevant data points from a set of data points with predicted positive labels.

$$PRECISION = \frac{TP}{TP+FP} \qquad (3)$$

There are several types of loss functions to evaluate the error gap between predictive output and the ground truth:

• Mean square error (MSE):

$$LOSS(t) = \frac{(Y'(t)-y(t)2]}{n} \qquad (4)$$

• Mean absolute error (MAE):

$$LOSS(t) = [|Y'(t) - y(t)| \ ]/N \qquad (5)$$

2.3. ARTIFICIAL NEURAL NETWORK:

An artificial neural network is a kind of series of algorithms which copies or mimic the human brain and finds the relationship between the sets of given data. Similar to a human mind has neurons interconnected to every different, synthetic neural networks additionally have neurons which might be related to every different in numerous layers of the networks. These neurons are called nodes. Artificial neural network are used in use cases which involves regression, classification and image recognition.
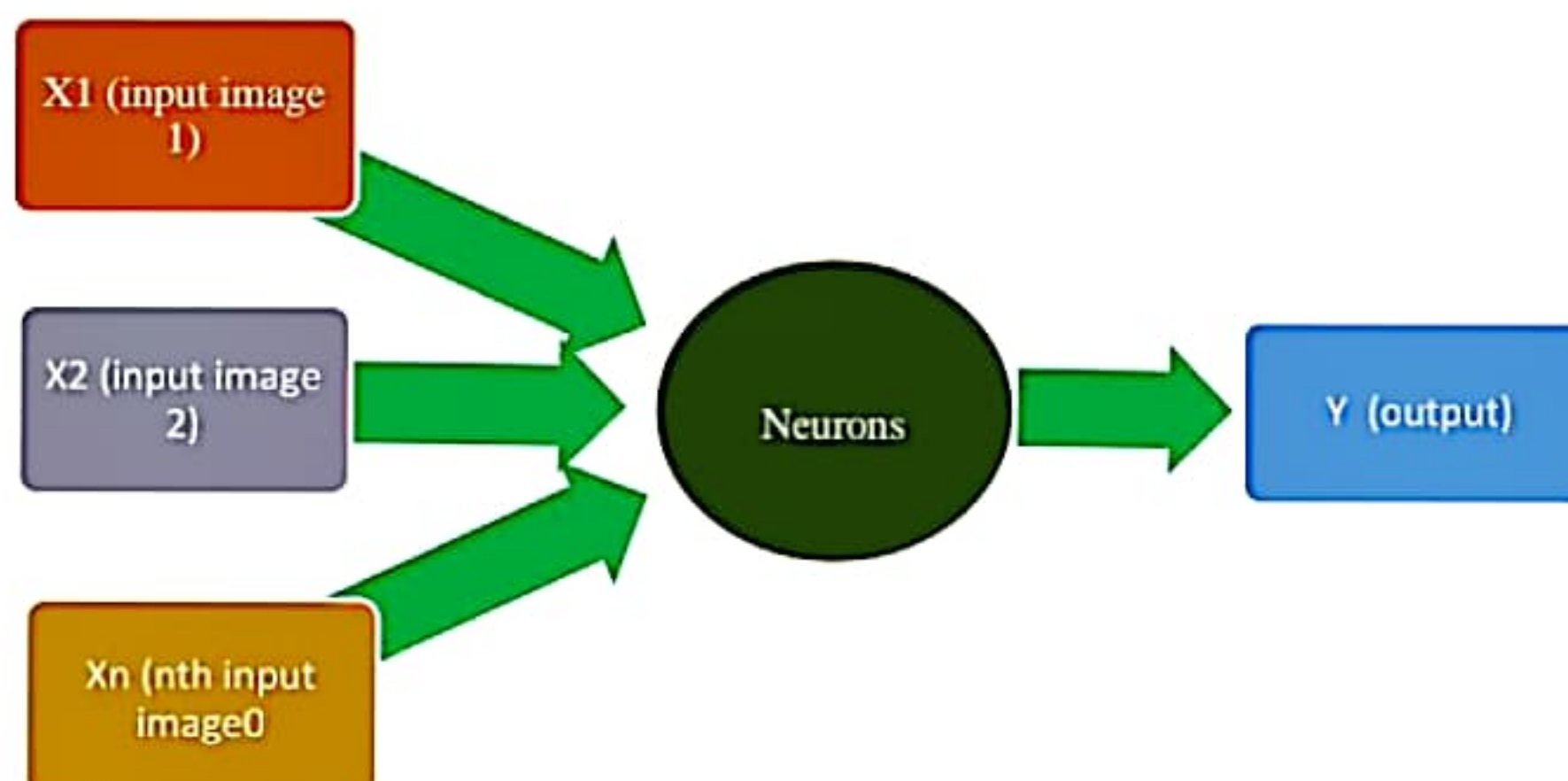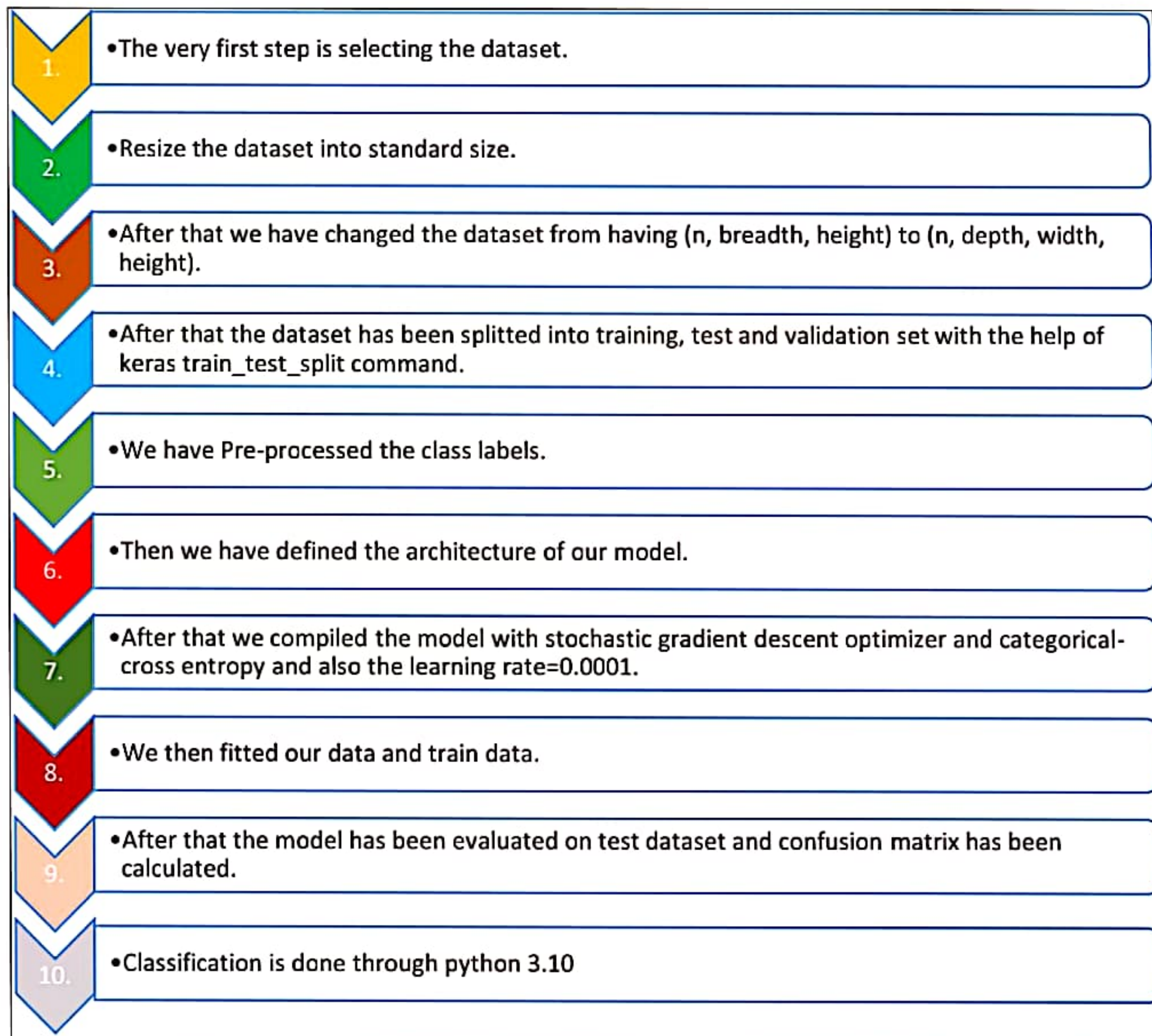
In Artificial Neural Network we can view the association between neurons outputs and neuron inputs as the directed edges with the weights. The Artificial Neural Network receives the input in the form of a pattern and image in the form of a vector. Then the input passed is multiplied by its corresponding weights. After that if we found that the weighted sum is equal to zero then we add bias to make the output as non-zero to scale up the system's response. The weight of the bias is equal to 1 and also it has same input [B-4].

ANNs have to be taught with a massive range of cases (records). Application of ANNs isn't always viable for uncommon or intense events, wherein records are inadequate to educate the model. ANNs do now no longer permit the incorporation of human expertise (professional opinion) to replacement for quantitative proof.

ANNs can contain uncertainties with the aid of using estimating the probability of every output node. However, the assumptions beneath which every output is maximum probably are unknown (i.e., neural networks are black boxes). Hidden layer nodes don't have any actual bodily meaning, so output can not be mapped without problems to process. ANNs additionally require a set direction of inference in which the choice on which data to process (inputs) and the way to classify it (outputs) is made in advance. To address nonlinearity troubles in DBP formation, ANNs had been used to expand predictive fashions for DBP formation in consuming water. They may be used for optimization, control, and comparing adjustments in DBPs formation. Moreover, it'll assist in desirable choice-making associated with layout and operation of consuming water centers to satisfy regulatory requirements.

3. Life Cycle of Fruit Classification:

This section is all about how the system is working and the flow of our work:

1. •The very first step is selecting the dataset.

2. •Resize the dataset into standard size.

3. •After that we have changed the dataset from having (n, breadth, height) to (n, depth, width, height).

4. •After that the dataset has been splitted into training, test and validation set with the help of keras train_test_split command.

5. •We have Pre-processed the class labels.

6. •Then we have defined the architecture of our model.

7. •After that we compiled the model with stochastic gradient descent optimizer and categorical-cross entropy and also the learning rate=0.0001.

8. •We then fitted our data and train data.

9. •After that the model has been evaluated on test dataset and confusion matrix has been calculated.

10. •Classification is done through python 3.10

4. CONVOLUTIONAL NEURAL NETWORK

Our project focusses on image classification and the efficiency of classifying images have been improved via computer vision and deep learning techniques. Since CNN is one of the great deep learning algorithm which is best suited for image classification. We have used a convolutional neural network for classifying different types of fresh and rotten fruits in which we pass an image as an input. After getting input features, it is passed to the neurons or the hidden layer. They are assigned weights. There are two types of operations that are performed inside the hidden layer. The first one is the summation of each weights with the input image i.e.

Step1: $Y = w1*x1 + w2*x2 + \dots + wn*xn + bias$ and second step is the activation. i.e.

Step2: $Act(y)$

The value of activation function i.e $\left(\frac{1}{1+e^{-y}}\right)$ will range between 0 and 1. If the values are less than 0.5 then the neurons will not get activated and if it is greater than 0.5 then the neurons get activated. The CNN was developed for image recognition tasks and was originally applied to handwritten digit recognition tasks. The basic design goal of CNN is to create a network in which neurons in the early layers of the network extract local visual features and neurons in the later layers combine these features to form higher-order features [B2].

The ReLU correction layer

ReLU stands for Rectified Linear Units. It acts as an activation function. RELU activation function is given by $F(U)=MAX(0, U)$.
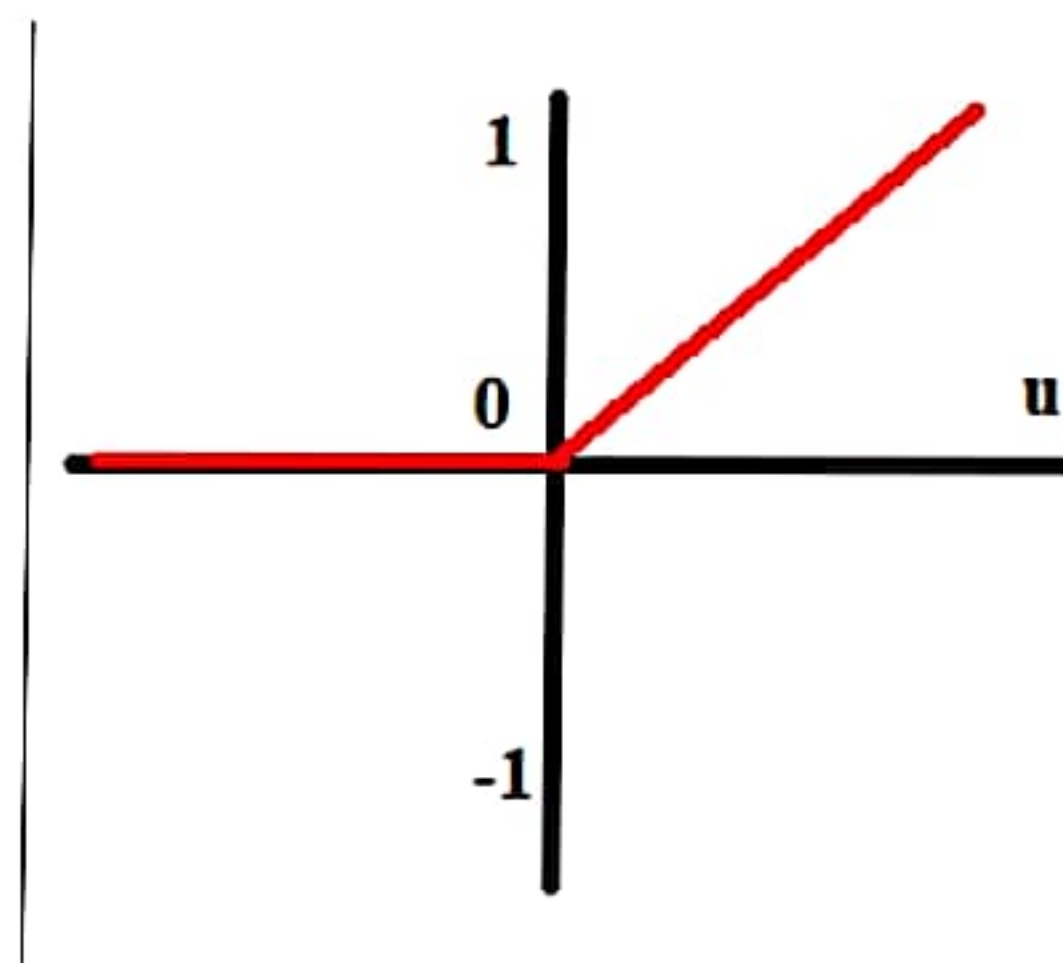

Fig 4. Relu function

If the value of U is negative, then $F(U) = 0$ and if the value of U is positive, then $F(U)$ is a positive value.

4.1 VGGNET (VISUAL GEOMETRY GROUP)

VGG is a popular deep Convolutional Neural Network structure with more than one layers. The deep refers back to the quantity of layers with VGG16 or VGG19. These includes sixteen and 19 convolutional layers respectively. The VGG structure is the idea of groundbreaking item reputation models. Developed as a deep neural community, the VGGNet additionally surpasses baselines on many duties and datasets past ImageNet. This is one of the maximum famous photograph reputation architectures. VGG structure: Input: VGGNet accepts photograph enter of 224x224 length. In the ImageNet contest, the author of the mockup reduce out a 224x224 patch withinside the middle of every photograph to maintain the dimensions of the enter photograph constant. [B2]

4.2 CONVOLUTIONAL LAYER:

The convolutional layer computes the convolutional operation of the input images using kernel filters to extract fundamental features. The kernel filters that are used are having the same dimension but the constant parameters are smaller as compared to the input images. Since it allows the same set of filter weights to be multiplied by the input array multiple times at different point on the image.

4.3 HIDDEN LAYERS:

All hidden layers withinside the VGG community use ReLU. VGG commonly does now no longer use neighborhood reaction normalization (LRN) as it increases memory usage and training time. Also, the overall accuracy does not improve.

4.4 FULLY CONNECTED LAYERS:

VGGNet has three fully connected layers. Of the three layers, the first two each have 4096 channels and the third layer has 1000 channels, one for each class. It act as a junction and within two different layers, it is used to connect neurons among them.

5. RESEARCH METHODOLOGY

There are various diseases that are caused to the humans when they intake rotten fruits. The foodborne diseases are to be given proper care for a healthy life. Fruits and vegetables are the main sources of nutrition in a high-risk neighbourhood. To protect them, it's crucial to be able to tell the difference between decaying and healthy fruits. Nowadays, automation technology is an inextricable element of existence. Their main source of income is agriculture. Every day, the market for fresh fruits expands. Only high-quality, wholesome raw fruits are chosen by health-conscious consumers. The fruit and food manufacturing industries are playing a more active role in the twenty-first century. Worldwide trade and natural product and vegetable request stream choose the nearness between exporters and merchants. For the exportation or importation of spoiled or nearly spoiled natural product, there's a long and time-consumed transportation strategy that blocks quality control of a tremendous number of natural products. As a result, natural product yield is anticipated to drop more compared with the world natural product generation and exchange of past a long time. Other primary causes of concern behind the decrease in commerce are not fair all other challenges, but moreover unstable environment patterns, climate alter, and temperature development. Other than, the nourishment industry has been genuinely impeded, aside from the send out and importation of new natural products, due to the observing of the nature of the spoiled natural products.

6 .RESEARCH OBJECTIVES

Computer vision has a broad variety of uses in the food processing units, enabling processes to be automated. Classification of fruits on the basis of their freshness is the very first aspect of the industries involved in making fruit products such as fruit juices etc.

- The main goal of our project is to propose a model which gives high accuracy such that detection of fruits can be simplified in agricultural sector. We have seen through our work that the Convolutional Neural Network performs very well in this type of work. In this study, we used two deep CNN architectures and one CNN-based MobilenetV2 architecture.
- With the help of various advanced techniques such as artificial intelligence, IoT, we will work upon our model to integrate with them which will automatically detect the freshness of fruits and will be able to classify the fresh and rotten fruits. We will be able to use such systems in different places including big factory super shops. We will make our work open source and open to all so that anyone can use it easily.

7. SYSTEM REQUIREMENTS

The various system hardware and software requirements which are required for our project are listed below:

Processor   : Any Processor above 500 MHz

RAM   : 512Mb

Hard Disk   : 10 GB

Input device   : Standard Keyboard and Mouse

Output device   : VGA and High Resolution Monitor

I. Anaconda:

Anaconda is a loose and open-supply distribution of the Python and R programming languages for clinical computing like data science, gadget gaining knowledge of packages, large scale information processing, predictive analytics, etc. that objectives to simplify package deal control and deployment. Anaconda Navigator is a computer graphical consumer interface (GUI) protected in Anaconda distribution that permits customers to release packages and manipulate anaconda applications, environments and channels with out the use of command-line commands. Navigator can look for applications on Anaconda Cloud or in a nearby Anaconda Repository, install them in an environment, run the applications and replace them. It is to be had for Windows, macOS and Linux. The following packages are to be had via way of means of default in Navigator: Jupyter Notebook, Qt Console, Spyder, PyQt

For this project will be using are Jupyter application, Flask, Html, Css:

A) Jupyter

Project Jupyter is a nonprofit employer created to "broaden open-supply software, open-standards, and offerings for interactive computing throughout dozens of programming languages". Spun-off from IPython in 2014 with the aid of using Fernando Pérez, Project

Jupyter helps execution environments in numerous dozen languages. Project Jupyter`s call is a connection with the 3 middle programming languages supported with the aid of using Jupyter, which can be Julia, Python and R, and additionally a homage to Galileo's notebooks recording the invention of the moons of Jupiter. Project Jupyter has evolved and supported the interactive computing merchandise Jupyter Notebook, JupyterHub, and JupyterLab, the next-era model of Jupyter Notebook.

Jupyter Lab is a internet-primarily based totally interactive improvement surroundings for Jupyter notebooks, code, and information. Jupyter Lab is flexible: configure and set up the consumer interface to assist a extensive variety of workflows in information science, clinical computing, and device learning. Jupyter Lab is extensible and modular: write plugins that upload new additives and combine with current ones.

The Jupyter Notebook is an open-supply internet software that permits you to create and proportion files that comprise stay code, equations, visualizations and narrative text. Uses include: information cleansing and transformation, numerical simulation, statistical modelling, information visualization, device learning, and lots more.

B) Flask

Flask is Python`s micro-framework for internet app development. It changed into evolved through Armin

Ronacher, who led an worldwide crew of Python fanatics referred to as Pocco. Flask includes Werkzeug WSGI toolkit and Jinja2 template engine. Both had been additionally evolved through Pocco. It changed into to start with launched in April 2010.

The Web Server Gateway Interface (Web Server Gateway Interface, WSGI) has been used as a wellknown for Python internet utility development

Features include:

Flask changed into designed to be smooth to apply and extend.

The concept at the back of Flask is to construct a strong basis for internet programs of various complexity.

Flask is tremendous for all types of projects, It`s in particular desirable for prototyping. Flask relies upon on outside libraries: the Jinja2 template engine and the Werkzeug WSGI toolkit.

ACTIVITY

Firstly we have collected our image data from wonderful website "kaggle". Then we went for data preprocessing part and we build a CNN model. Then we train CNN model and evaluated our model. The architecture of the proposed model is in fig 4.
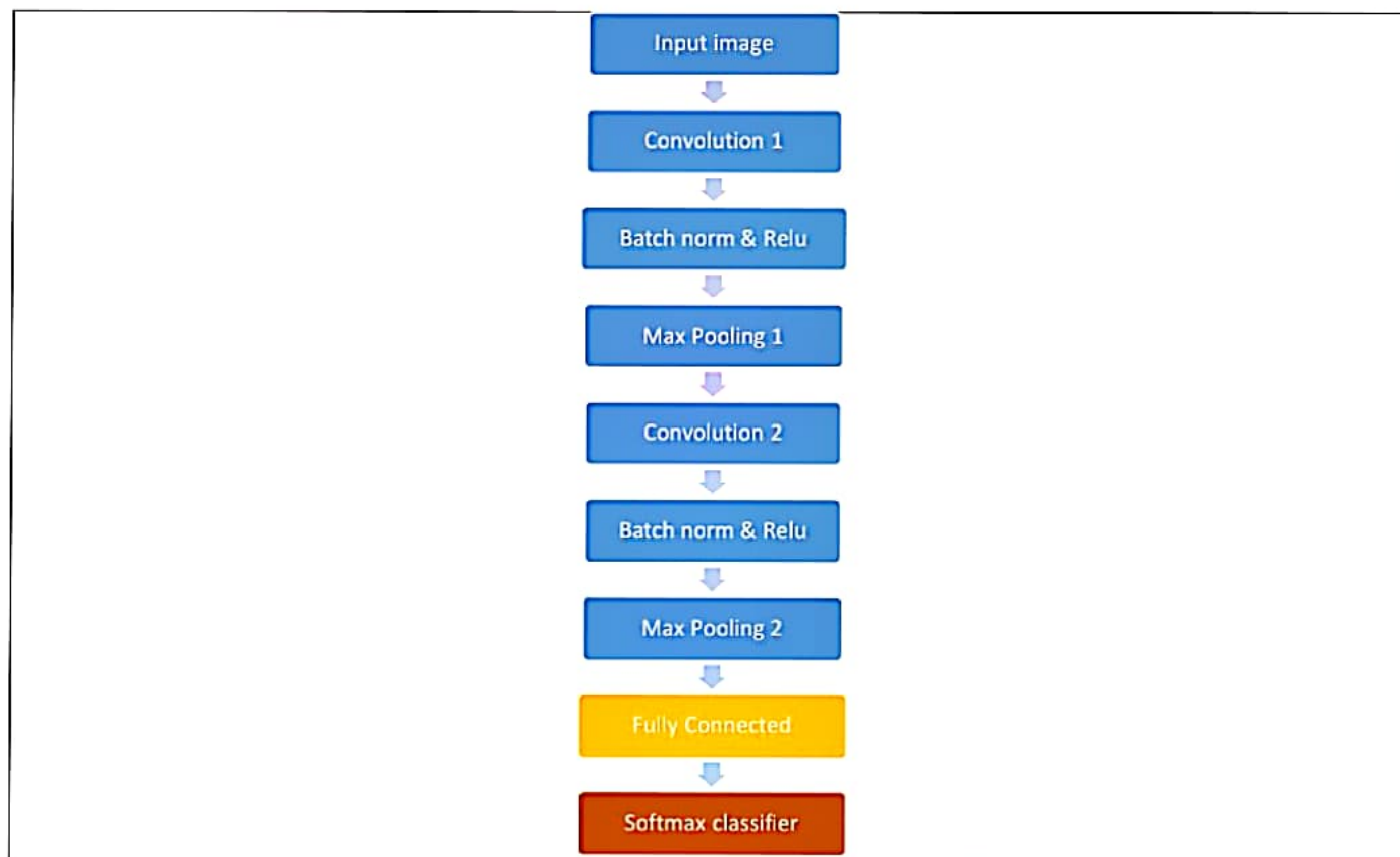
Fig 5. Architecture of proposed model.

8. SYSTEM IMPLEMENTATION

8.1 Data collection procedure:

The very first and the basic stage of any data classification techniques is collecting data. The source of data should be valid and legal. So we collected our data from one of the wonderful websites "kaggle" [A].

The dataset basically consists of three types of fruit images i.e. Apple, Banana, Oranges. These fruits are further classified into six categories, each one as fresh and rotten. The total image counted were approx. 6000 images. Further the dataset was classified into training, validation and test dataset which includes 3600 images, 600 images, 1797 image respectively.

8.2 Statistical Analysis

Our general photograph records is extra then 6000 that we collected. After pre-processing we get general records is 5989. Total correct records quantity are given below.

Table 1. Train image data amount

Fruits name	No. of fruits
Rotten orange	1595
Rotten banana	2224
Rotten apple	2342
Fresh orange	1466
Fresh apple	1693
Fresh banana	1581

Table 2. Test image data amount

Fruits name	No. of fruits
Rotten orange	403
Rotten banana	503
Rotten apple	601
Fresh orange	388
Fresh banana	381
Fresh apple	398

8.3 Data Pre-processing

Data processing is a completely important state. Data processing after statistics collection becomes very important for image classification-related problems. We have divided our statistics set into eighty percent training and the rest for testing. We gather more than 10000 image data from specific property and try and useless or noisy statistics. Since we've used RGB pix, it's miles endorsed that all of these pix have the same length & shape. We used 32x32x3 for this set.
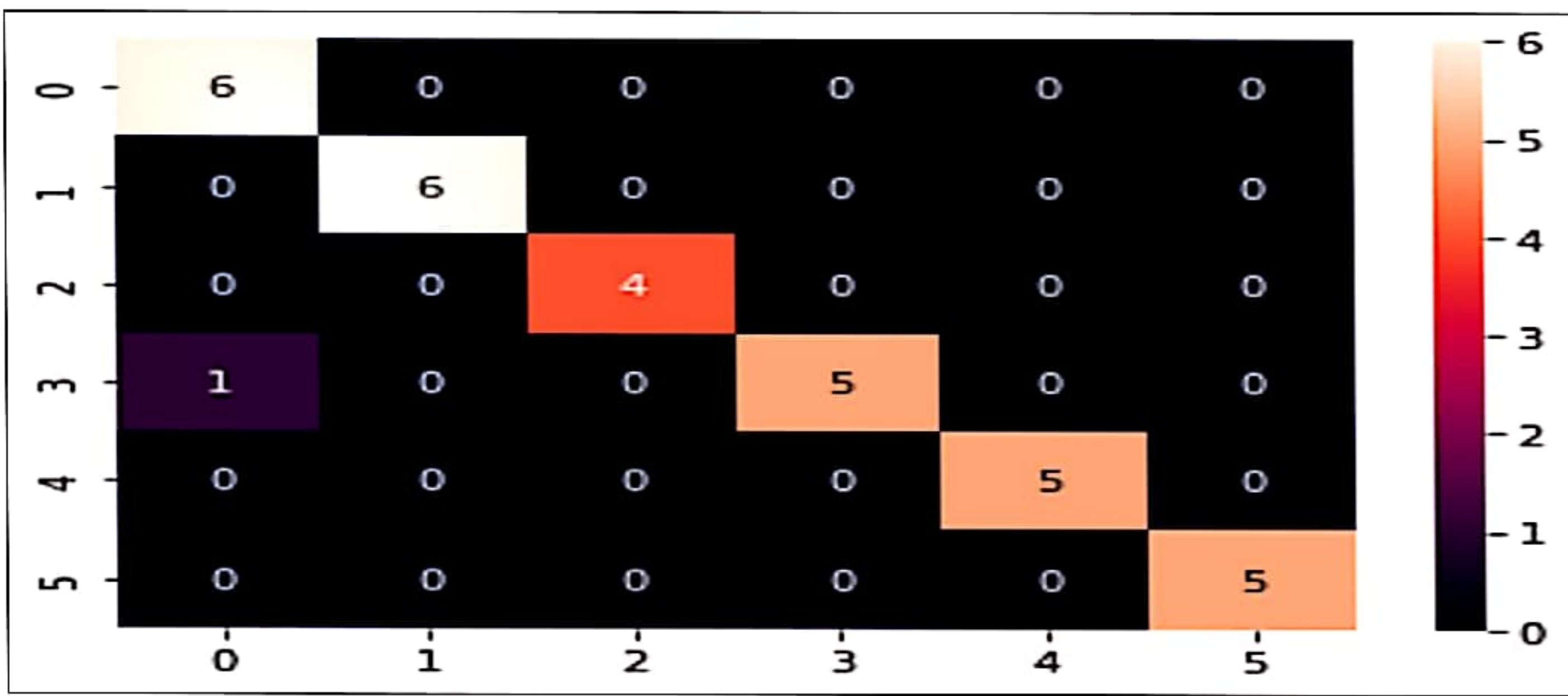
Fig 6.   Visualizing dataset

8.4 Data Organizing

Data augmentation is basically the transformation of the input images which is to be passed in Convolutional neural network. Basic transformation involves flipping, horizontal and vertical shifting. By transforming input images we are basically making our CNN model more robust to input i.e. it can predict well. Data Augmentation is basically done when our dataset is over fitting the model. Over fitting occurs when our model corresponds too similar to the training dataset and fail to fit additional data which affects the accuracy of predicting test dataset. As some distance our dataset is confined we can be get hassle in over fitting. For putting off over fitting we put into effect data augmentation. In this section we divided statistics and preserve them in data folder test and train, we moreover use proper right here validation folder for take a look at train statistics validation. Then we divided those test and train folder`s statistics in extra folder like fresh apple, rotten apple, fresh banana or rotten banana etc.

8.5 Labeling Data

After the data is organized we renamed the image dataset and sequentially numbered them.

8.6 Model flow

CNNs work with properly sized components. First is the extraction of functions, then the classification. The convolutional layer used for feature extraction and the fully connected layer used for classification. Introduced in the proposed version 2 convolution layer, two pooling layers. First, CNN captures a 32x32x3 image. To achieve better results, RGB channels are used here. In first convolutional layer clear out length of 32 with 3x3 kernel introduced with a ReLU activation characteristic to including nonlinearity. Now to reduce the dimensionality we later used a maxpooling length of 2X2. Filter length of sixty four with 3x3 kernel used once more with a ReLU activation in 2nd convolutional layer. Later we used 2x2 max pooling. After the fourth shift, we will further reduce the dropout price by 0.35. A knockdown plane for creating 2D sequences in a 1D matrix. Later, a fully connected Layer 128 node with ReLU enabled will be used. Again, a dropout price of 0.25 is used to reduce overshoot. Finally, a dense layer of six devices used with delicate ax activation for classification.
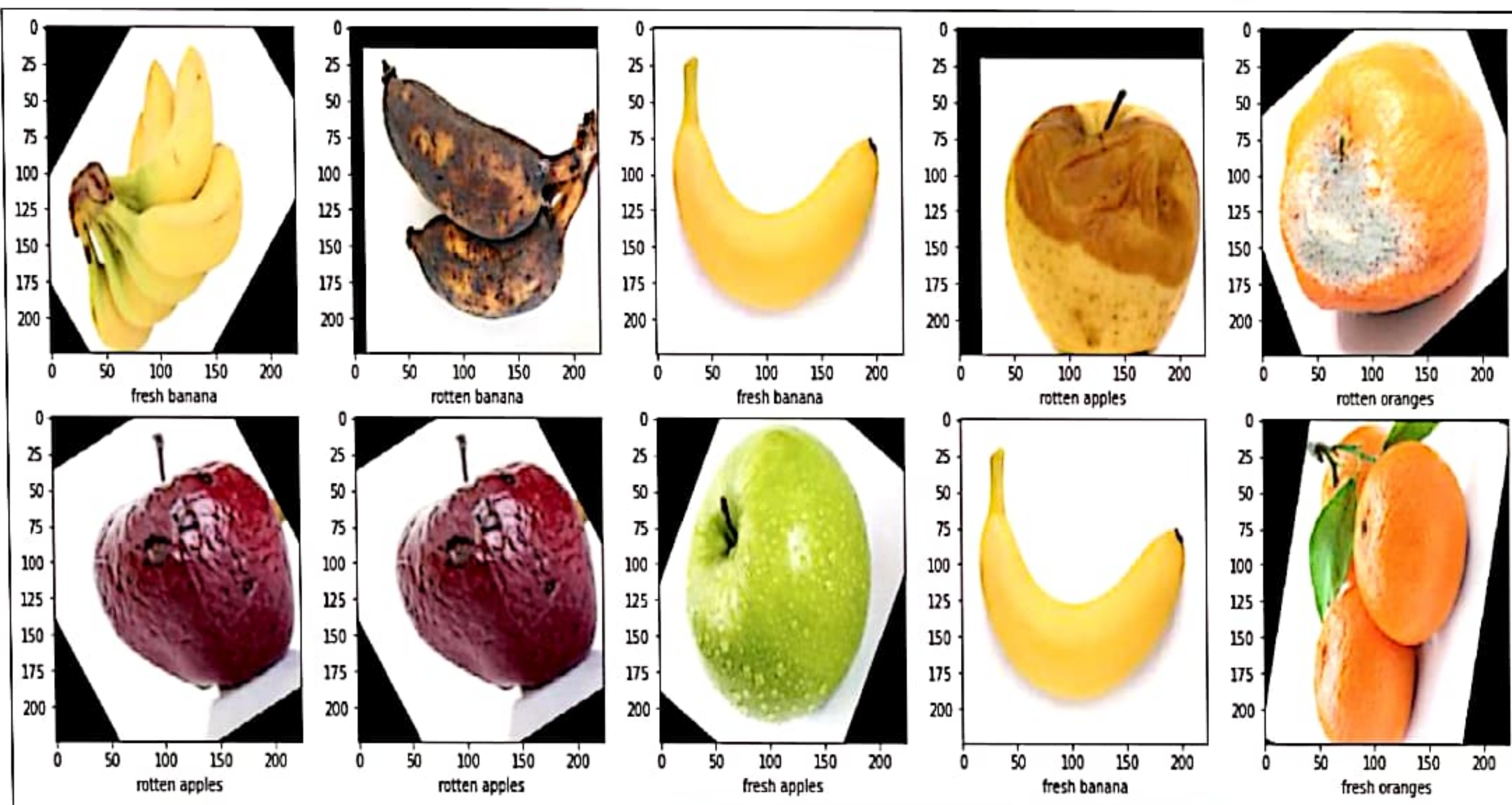
Fig. 7: Sample test dataset.

9. RESULT

9.1. EXPERIMENTAL SETUP

In this section, we can typically examine the end result of the proposed version of our work and provide an explanation for the end result of our findings with right logic. We have used the tensorflow version. Setting hyper parameters to our version changed into the primary step. Define Batch length as 45. We set the ratio of our training and testing dataset to be as 80% and 20% respectively. After dividing the dataset into training and testing we compiled our version with the use of adam optimizer and our learning rate(alpha) changed into 0.0001. After that we used FIT () function to start with the training with the given dataset.
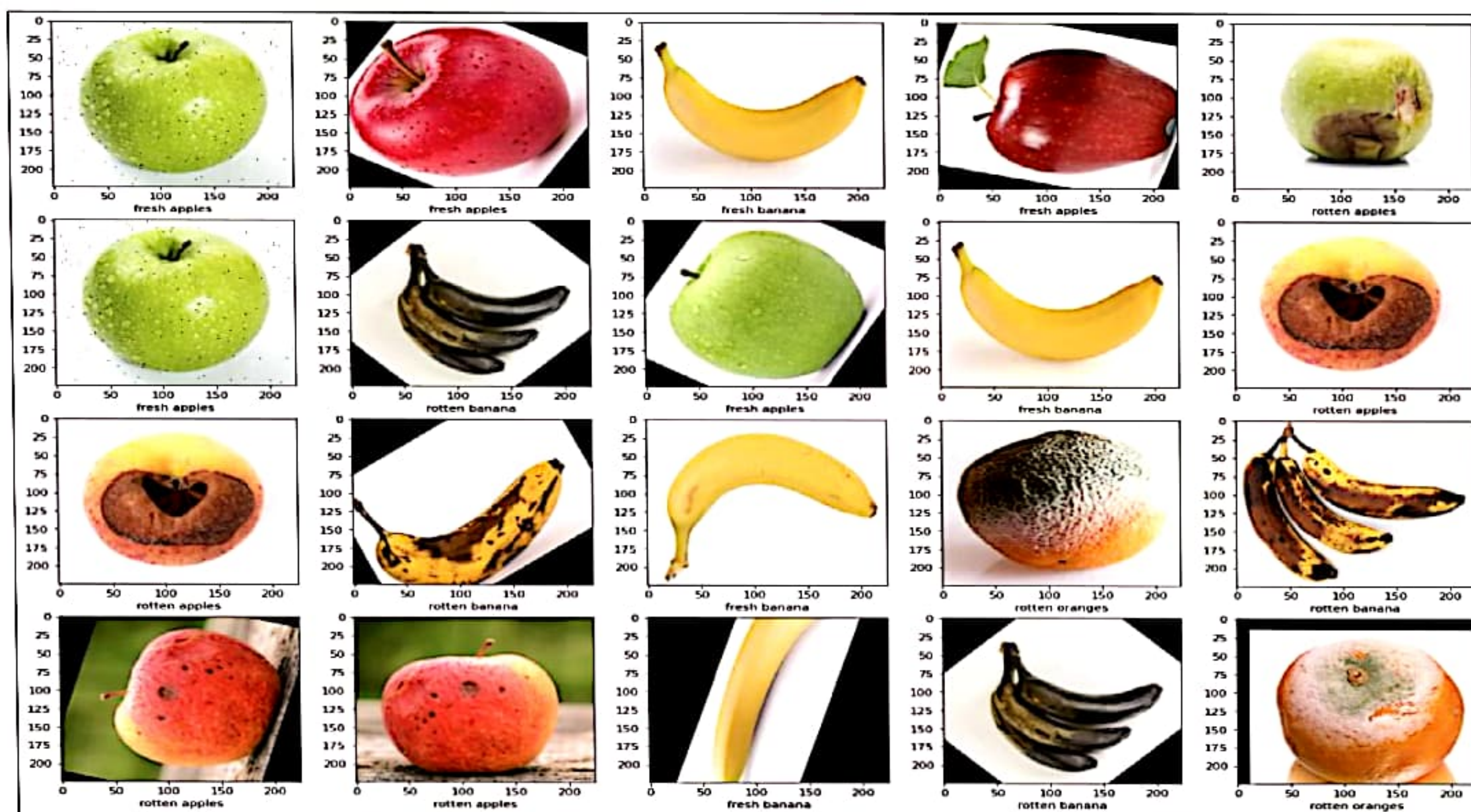
9.2. PERFORMANCE EVALUATION

So, after whole lot of work when finishing the training of our CNN model, the important part was checking the accuracy of our model. So, our model success with an accuracy of 98.04%. Hence, Fig 7 depicts the accuracy curve of our model. Here we observed that our model has training accuracy as 98.04% and validation accuracy as 98.21%.
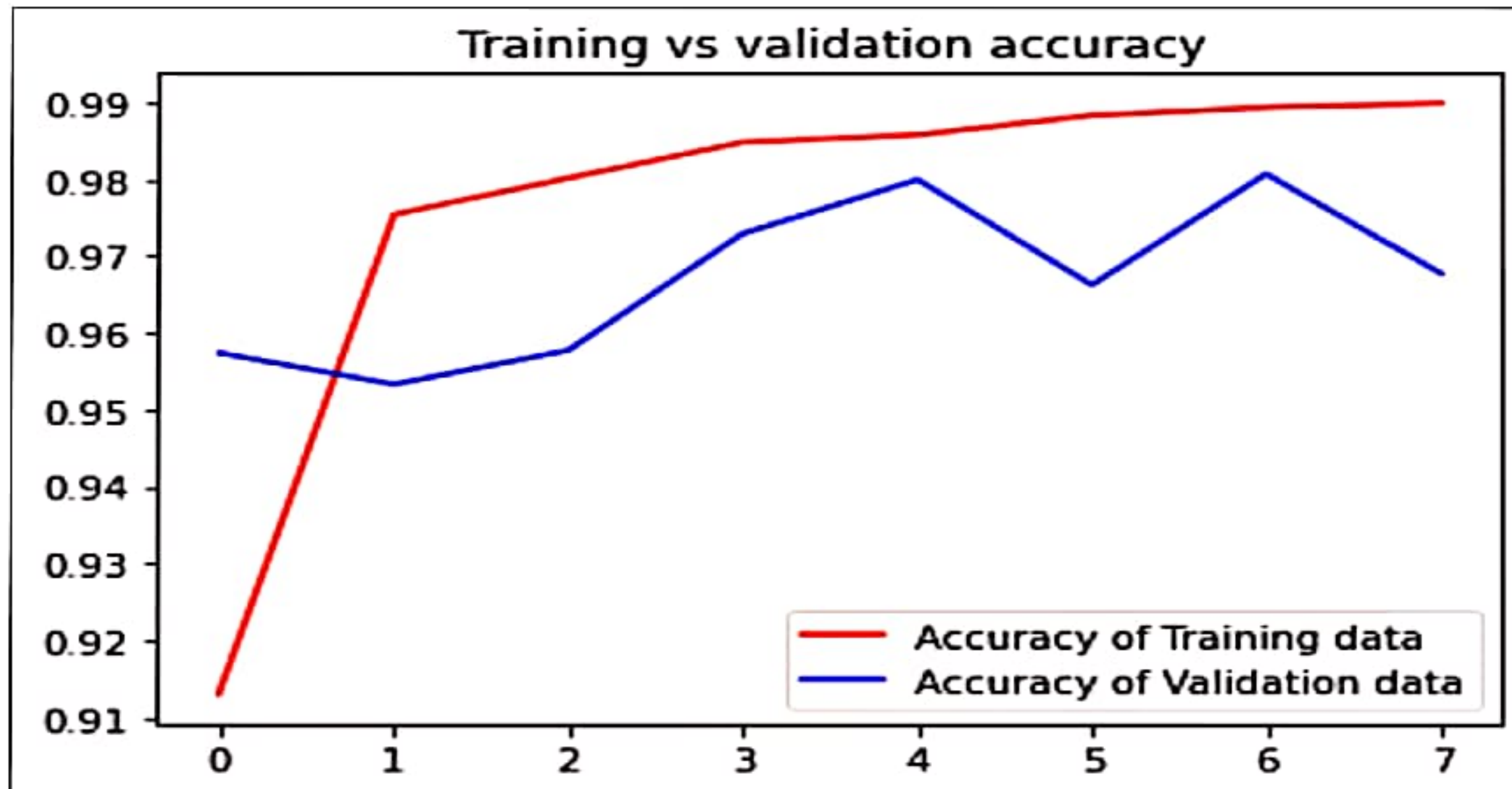

Fig. 9: Training accuracy vs Validation accuracy

The loss curve of our model is depicted in fig.8 where the training loss is observed to be 0.054 and validation loss is observed to be 0.079.
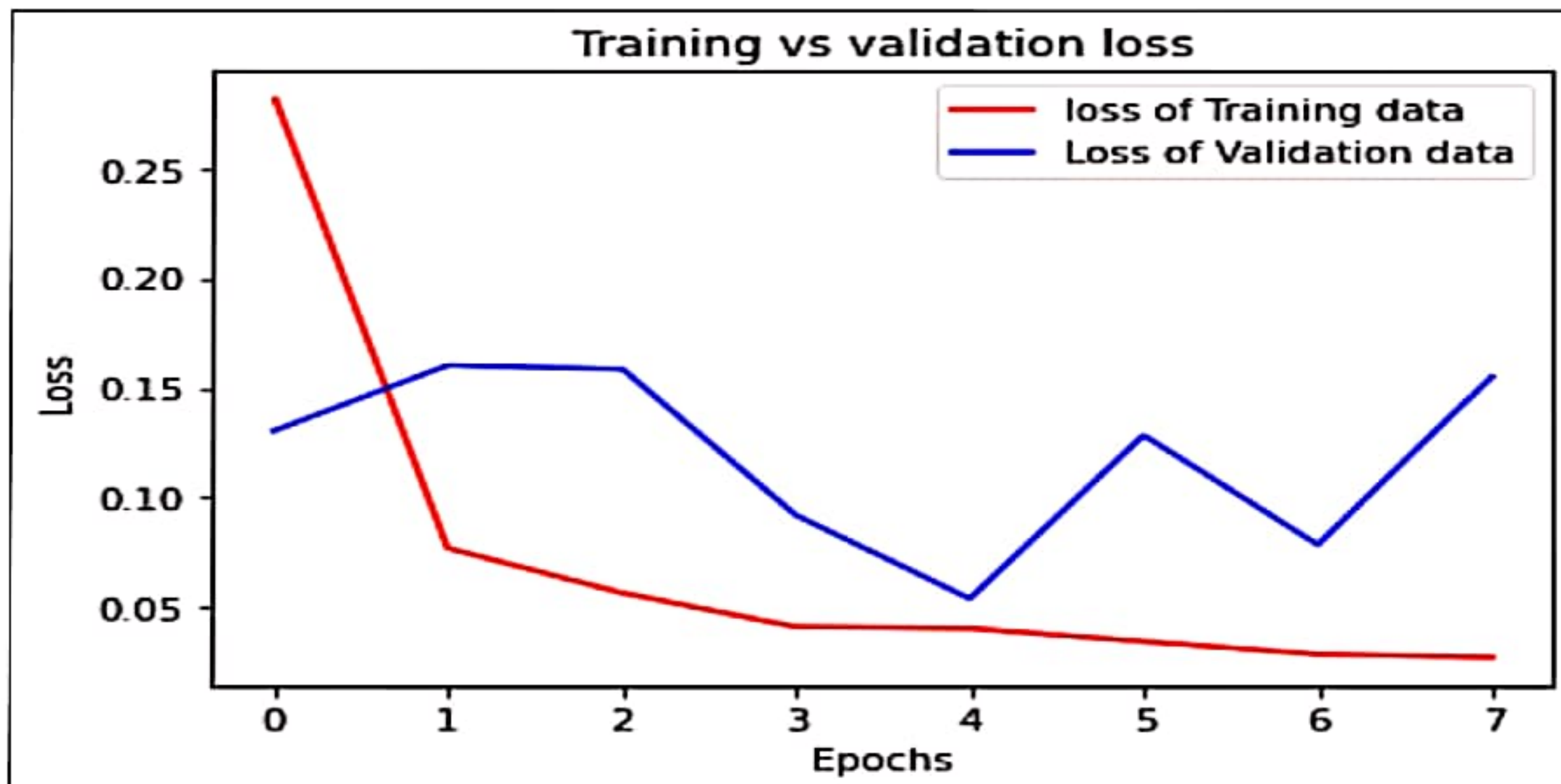

Fig.10. Training loss vs Validation loss

After we received the accuracy of our CNN model we have implemented flask framework to make this model a web application so that we can host it in our local server. We further used bit of HTML and CSS for frontend styling purpose of our web application

Fig 11. Web application for predicting images.

10. CONCLUSION

This paper basically focuses on the use of convolutional neural network in the food industry. CNN gave us constructive and unbiased classification of fresh and rotten fruits. In this research paper we use CNN version to do it flawlessly and supply a super result. It will honestly assist human beings to understand which fruit is ideal and which one is bad. In our country the brand new era nearly 95% of human beings are developing up without expertise on shopping for fruit products. So in our work we display 3 essential fruits to understand how can guarantee a fruit is rotten or fresh. And we get first rate and desirable accuracy stage through the use of it. We received 98.04% accuracy for the given proposed version.

Hence, to achieve the real world application demands, the CNN technique used will efficiently increase the classification of fresh and rotten fruits.