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RESEARCH ARTICLE

Fruit Image Classification using Convolutional Neural Network

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ABSTRACT

Fruit classification has been increased due to different varieties of fruit come to the market in large quantities. Manual Classification consumes more time and it is a tedious job to classify the tons of fruit in shorter time. Hence there is a need of vision based fruit classification which also reduces the labor and packaging expenses. The dataset which has 28736 fruit images of 60 categories. To prove CNN is the best classification, here classification was done on neural and deep neural networks. By comparing the accuracy of these two we prove that CNN is the best one.

Keywords- : Fruit classification, Neural Network, Deep neural Network Convolution Neural Network

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INTRODUCTION

Classification of fruits is a tedious job in the markets. Since different types of fruits are arriving to the market now a days. It is very interesting that classifying the fruits in image pose. Also It is challenging one to classify the fruit in images .Since some similarities, variability will found in the images. Example: Apple and pomegranate resembles same in the shape and color so it is tedious for the computer to classify. Also problem will arise between ripen fruit images .Fruits are non-rigid object it will deform in any ways. Due to the light, temperature changes the shape of the fruit will be changed. So it is very challenging to classify the fruits in image pose. In this paper, we have to prove that CNN is the best one for the classification. To prove this, we done the classification on neural networks and deep neural network from the results of these two we are prove that CNN as the best classifier.

LITERATURE REVIEW

Zawbaa H. M., Hazman M., Abbass M. and Hassanien A. E., "Automatic fruit classification using random forest algorithm", in this paper the classification was done on Random forest. SIFT technique used for the feature extraction. Classification carried out for the 3 types of fruits.

Jasmeen Gill, Dr.Parvinder Singh Sandhu, and Dr.Tejwant Singh, "A Review of Automatic Fruit Classification using Soft Computing Techniques" In this paper the classification was done on soft computing techniques like image processing, neural networks, fuzzy logic. Classification carried out for the ten types of fruits.

Yudong Zhang and Lenan Wu, "Classification of Fruits Using Computer Vision and a Multiclass Support Vector Machine "In this paper the classification was done on multi-class Kernel Support vector Machine(KSVM). Three types of kernel used for the classification "Linear kernel, Homogenous polynomial kernel, Gaussian Radial Basis Kernel". Classification done for 18 types of fruit.

Ms. Snehal Mahajan, Prof. S. T. Patil "Optimization and Classification of Fruit using Machine Learning Algorithm". In this paper fruit image are classified with support vector machine and genetic algorithm. For optimization genetic algorithm and classification Support vector machine is used. The classification done for only three fruits like apple, banana, grape. In feature extraction shape, texture, colour characteristics are extracted.

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PROPOSED METHOD

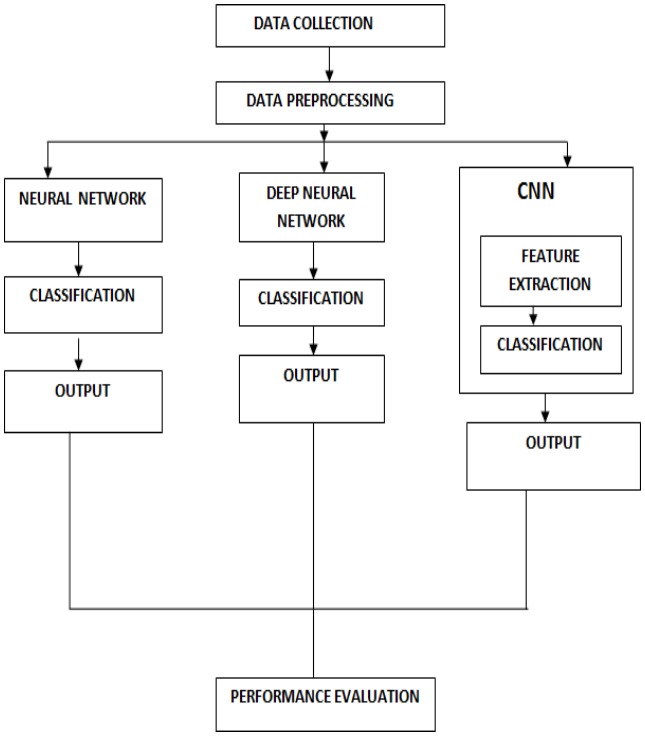

FIG-1: FLOWCHART OF PROPOSED METHOD

Dataset

The dataset was collected from Fruits-360.Dataset which has fruit images of 28736 on 60 categories.

Table-1: Fruits in the dataset

1	Apple Braeburn	16	Cactus Fruit	31	Kiwi	46	Pear
2	Apple Golden1	17	Carambula	32	Kumquats	47	Pear Abate
3	Apple Golden2	18	Cherry	33	Lemon	48	Pear Monster
4	Apple Golden3	19	Clementine	34	Lemon Meyer	49	Pear Williams
5	Apple Grany smith	20	Cocos	35	Limes	50	Pepino
6	Apple Red1	21	Dates	36	Litchi	51	Pineapple
7	Apple Red2	22	Granadilla	37	Mandarine	52	Pitahaya Red
8	Apple Red3	23	Grape Pink	38	Mango	53	Plum
9	Apple Delious	24	Grape white	39	Maracuja	54	Pomegranate
10	Apple Red Yellow	25	Grape white2	40	Nectarine	55	Quince
11	Apricot	26	Grape fruit white	41	Orange	56	Raspberry
12	Avacado	27	Grape fruit pink	42	Papaya	57	Salak
13	Avacado Ripe	28	Guva	43	Passion Fruit	58	Strawberry
14	Banana	29	Huckleberry	44	Peach	59	Tamarillo
15	Banana Red	30	Kaki	45	Peach Flat	60	Tangelo

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Dataset Properties

1. Traning set size :28736 images
2. Validation set size :9673 images
3. Number of classes :60
4.Image size :100*100 Pixels

Fig-2: Fruits dataset

Data Preparation

1. Resize
2. RGB to BGR
3. Normalization
4. Label encoding
5. Split Training and validation set

Resize

The image in the dataset is of size 100*100 pixels. It take more time to load the data. So the size of the image is reduce to 45*45*3 in 3D matrices. Resizing will discard unneeded pixel information from the image and also reduce the mega pixel count of the image. Eras package requires an extra dimension in the end which correspond to channels. For RGB image, there is 3 channels so the image is reshape into 45*45*3.

RGB TO BGR

The open CV stores the channel value in BGR, which means Red have the least area, Green have second least area and Blue have third least area. So it supports BGR model. BGR is supported by many graphic APT for compatibility. BGR is a 24-bit representation. Open CV expects M*N*3 image as BGR and it begins with default BGR pixel format. To load image the color information is stored in the order of Blue-Green-Red instead of RGB.

Normalization

Gray world normalization makes the assumption that changes in the lightening

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spectrum can be modeled by three constant factor applied to red, green, blue channels of color. Gray world will reduce the effect of

Illumination differences. In the image value to color channel [0-255].It is difficult to converge fast. Value of color channel should reduce to [0-1].Divide the color values between o to1.

Label encoding

Labels are of 60 fruit images numbered from 0 to 59.Unique category value is assigned an Integer value. "APPLE-0".One-hot – Encoding is an integer encoded variable is removed and a new binary value is added for each unique integer value (0,1).the Columns and the presence of a class will be represented in the binary format.

Table-2: One-hot-encoding

Red	Green	Blue
1	0	0
0	1	0
0	0	1

1. **Split training and validation set**

For training ,28736 image are there with 3D-5*45*45*3

For Validation ,9672 images are there with 3D-45*45*3

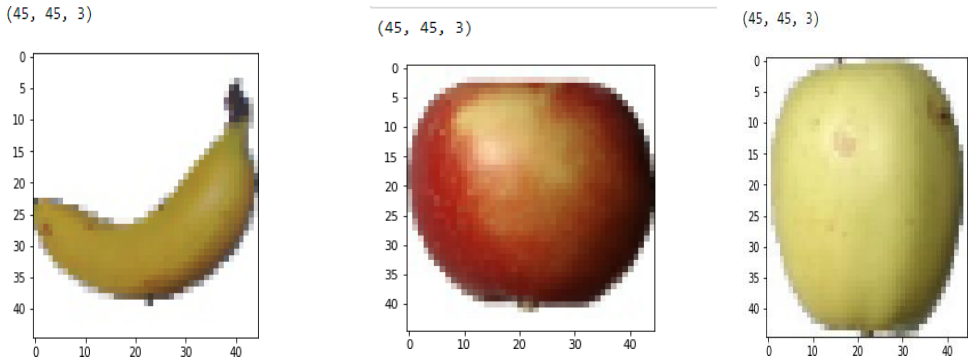

Fig-3: Data Preparation

Neural Network

Neural network is designed in such way to recognize the pattern and classification. It is capable of learning on their own and adapting to changing condition. It has three important layer Input, Hidden, Output.

Input Layer: The activity of input units represents the row information that is fed into the network.

Hidden Layer: The activity of each hidden unit determined by the activities of the input

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units and weights on the connection between input and hidden units.

Output Layer: The behavior of the output units depends on the activity of the hidden units and the weight between the hidden and output units.

Neural network is limited to one or two hidden layers. Every hidden layers tries to detect pattern on the image. When a pattern is detected next layer is activated. First layer is used to detect edges found in the images.

Feed Forward Network: This algorithm helps in pattern recognition.

The information moves in only one direction. Forward from the input nodes through the hidden nodes and to the output nodes. There is no cycles or loops in the network. Feed forward tends to be straight forward network that associate inputs with outputs.

Three dense layer and 2 dropout layer is used in the neural network .Dense Layer is a fully connected layer used for the neural network classification. Every node in the layer is connected to every node in the preceding layer. A linear operation on the layer input vectors. Every input is connected to every output by weight. Droupout layer is a regularized technique for reducing over fitting in neural network .It is used to improve over-fit on neural network also used in hidden neurons and input layer

Layer (type)	Output Shape	Param #
dense_1 (Dense)	(None, 128)	777728
dropout_1 (Dropout)	(None, 128)	0
dense_2 (Dense)	(None, 64)	8256
dropout_2 (Dropout)	(None, 64)	0
dense_3 (Dense)	(None, 60)	3900

Fig-4: Layers in Neural networks

Deep Neural Networks

Deep neural network are distinguished from the more common place single- hidden layer by their depth. More than three layers (including input and output) qualifies as Deep neural network (i.e) more than one hidden layers. Each layer nodes trains on a distinct set of feature based on the previous layer output. It will train the layers one by one from input to output layer. It is capable of handling very large, high-dimensional data sets and classify according to the similarities. It will perform automatic feature extraction without human intervention. Same feed forward network is used here for the pattern recognition.

Deep neural networks use sophisticated mathematical modeling to process data in complex ways.

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In the deep neural network more than 3 dense and dropout layer is used for the classification;

Layer (type)	Output Shape	Param #
dense_4 (Dense)	(None, 256)	1555456
dropout_3 (Dropout)	(None, 256)	0
dense_5 (Dense)	(None, 128)	32896
dropout_4 (Dropout)	(None, 128)	0
dense_6 (Dense)	(None, 128)	16512
dropout_5 (Dropout)	(None, 128)	0
dense_7 (Dense)	(None, 128)	16512
dropout_6 (Dropout)	(None, 128)	0
dense_8 (Dense)	(None, 128)	16512
dropout_7 (Dropout)	(None, 128)	0
dense_9 (Dense)	(None, 60)	7740

Fig-5: Layers in Deep Neural Network

Convolution Neural Network CNN, one of the most commonly used deep learning methods becomes popular because of its outstanding performance on object recognition. It trains the description features of the data. Then, the CNN classifier classifies fruits group of the particular types. CNN consists of neurons. Each neurons receives inputs from the image. Neurons are arranged in 3dimensions width, height, and depth. Filters are applied to each training image at different resolutions, and the output of each convolved image is used as the input to the next layer.

The process of building convolutional neural networks always involves four major steps:

1. Convolution
2. Pooling
3. Flattening
4. Dense

Convolution Layer

The convolution layer is the core building block of a convolutional network that does most of the computational. It is the eyes of CNN. Input image to the layer will be (m*n*r) where m –height,n-width,r-number of channels(RGB). This layer consists of learnable filters. It has K filters of size n*n*q where n-smaller than the dimension

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of image, q-number of channels. When we convolve each filters across the width and height of input volume in 2D.Network will learn filters that activate the visual feature such as edge, color.

Parameters

Depth: It is a hyperparameter.It will tell us about number of filters we like to use.

Strode: Which will slide the filters. When S=1 move the filters one pixel at time. This will produce smaller output volumes spatially.

Zero Padding: To pad the input volume with zero around the border. It is a hyper parameter. It will control the spatial size of the ouput volumes.

Pooling Layer

This Layer is inserted in between the successive convolution layers.Funct6ons progressively to reduce the spatial size of the representation, parameters, computation in network and controls over fitting. The parameters used in this layer are Stride and Filters. There are several non-linear functions are available to implement pooling they are MaxPooling, MinPooling, Average Pooling.

1.max()-It looks at the 2 neighboring pixels and picks the maximal value.
2.min()-It picks the minimal value
3.avg()-It takes the average of max and min value.

Flattening Layer

Flattening is the process of converting all the resultant 2 dimensional arrays into single long dimensional vectors. This layer reduces the file size. It combines all the layers into a single background layers .The layers cannot modify after flattened. This flattening step is needs so that you can make use of the fully connected layers after some convolutional/maxpool layers.

Fully Connected Layer

It is used to perform the full connection of the convolutional network. Connect every neuron in one layer to every neuron in another layer. After several convolutional and max pooling layers, the high level reasoning in the network is done via fully connected layer. Neurons in a fully connected layer have connection to all activation in the previous layer.

Activation Functions

Activation function determines what output a node generate base upon its input. It set at the layer level and applies to all neuron in that layer. It is add to the output end of the any node. Used to determine the output of network like Yes or no. It maps the resulting values between 0 to1.

1. **RELU**-Rectifier Linear Unit used in the hidden layers. Output cannot be confined between any ranges. It will map the negative values into zero or positive values. It is use to add non-linearity to the network.
2. **SOFTMAX**-Used for multi -class classification (i.e.) any number of classes. Used in different layers of network.

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Layer (type)	Output Shape	Param #
conv2d_1 (Conv2D)	(None, 43, 43, 32)	896
conv2d_2 (Conv2D)	(None, 41, 41, 64)	18496
max_pooling2d_1 (MaxPooling2	(None, 20, 20, 64)	0
dropout_1 (Dropout)	(None, 20, 20, 64)	0
flatten_1 (Flatten)	(None, 25600)	0
dense_1 (Dense)	(None, 128)	3276928
dropout_2 (Dropout)	(None, 128)	0
dense_2 (Dense)	(None, 60)	7740

Fig-6: Layers in Convolution Neural Networks

Implementation

In order to create our convolutional neural network we used Tensor Flow. This is an open source framework for machine learning created by Google for numerical computation using data flow graphs. Nodes in the graph represent mathematical operations, while the graph edges represent the multidimensional data arrays called tensors. The main components in a Tensor Flow system are the client, which uses the Session interface to communicate with the master, and one or more worker processes, with each worker process responsible for arbitrating access to one or more computational devices (such as CPU cores or GPU cards) and for executing graph nodes on those devices as instructed by the master. Tensor Flow offers some powerful features such as: it allows computation mapping to multiple machines, unlike most other similar frameworks; it has built in support for automatic gradient computation; it can partially execute sub graphs of the entire graph and it can add constraints to devices, like placing nodes on devices of a certain type, ensure that two or more objects are placed in the same space etc.

RESULTS

Fruits images are classified with help of fruit- 360 dataset. The dataset consist of 28736 fruit images on 60 types. Classification is carried out by three techniques: Neural Networks, Deep Neural Networks, and Convolutional Neural Network. Among these three the CNN gives the best results. With help of categorical Accuracy the accuracy is calculated.

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```
Test accuracy: 0.8643507030603805
```

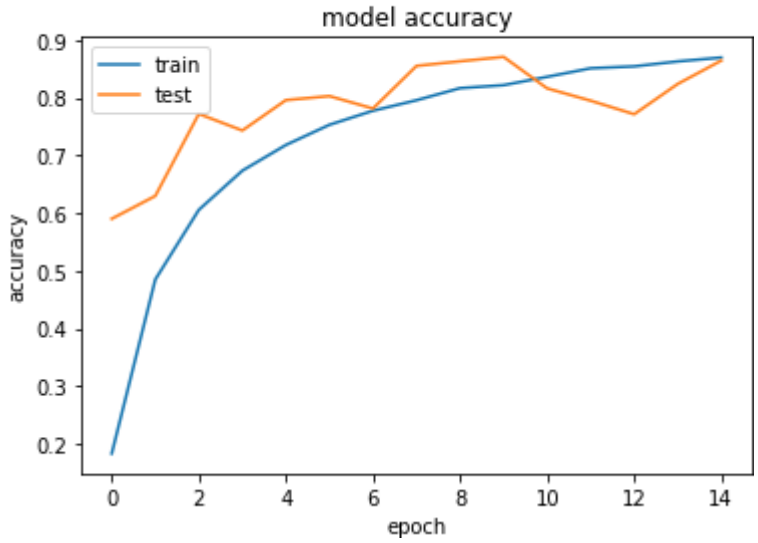

Fig-7: Neural network accuracy

```
Test loss: 0.448049903830655
```

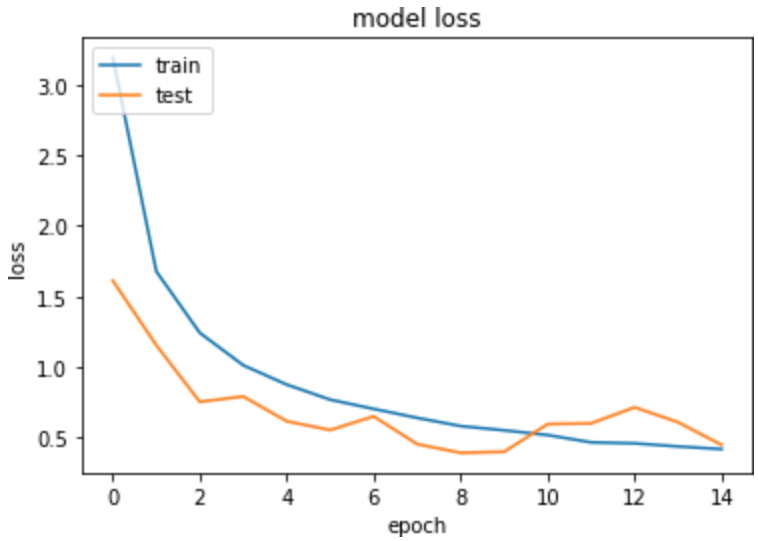

Fig-8: Neural network loss

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Deep Neural Network

```
Test accuracy: 0.935690653432589
```

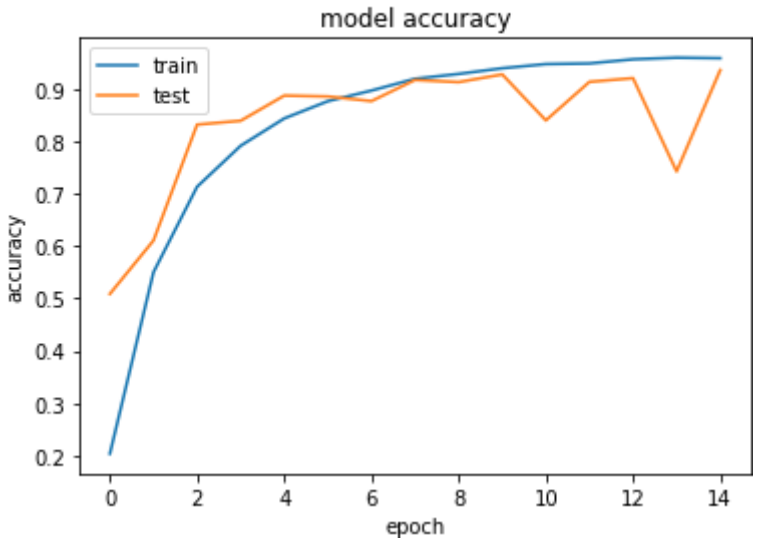

Fig-9: Deep neural network accuracy

```
Test loss: 0.30367247452350105
```

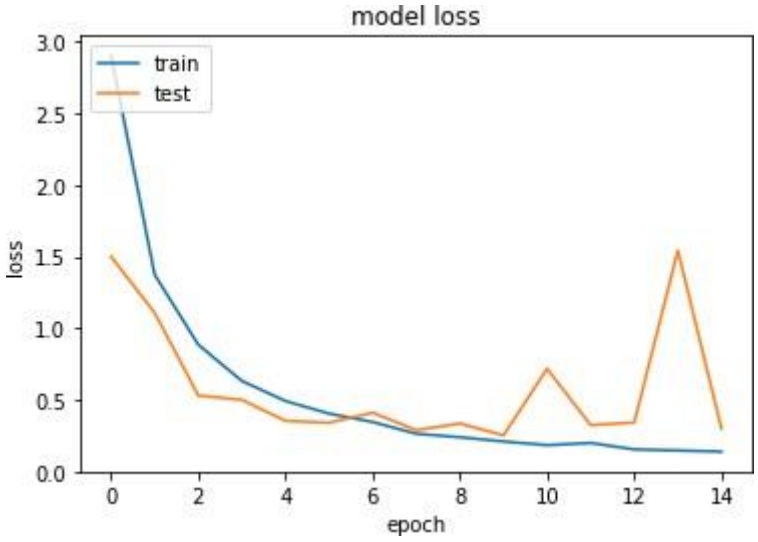

Fig-10: Deep neural network loss

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Convolution Neural Network

```
Test accuracy: 0.972394540942928
```

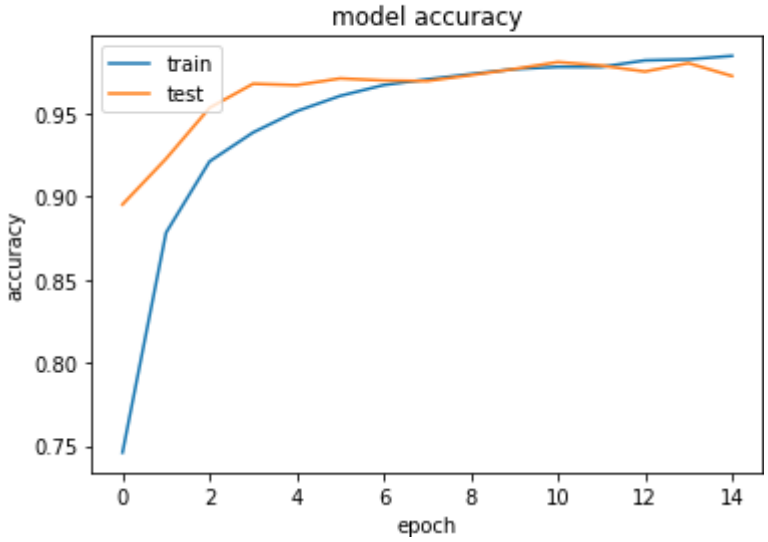

Fig-11: convolution neural network accuracy

Neural Network

```
Test loss: 0.09326224259820587
```

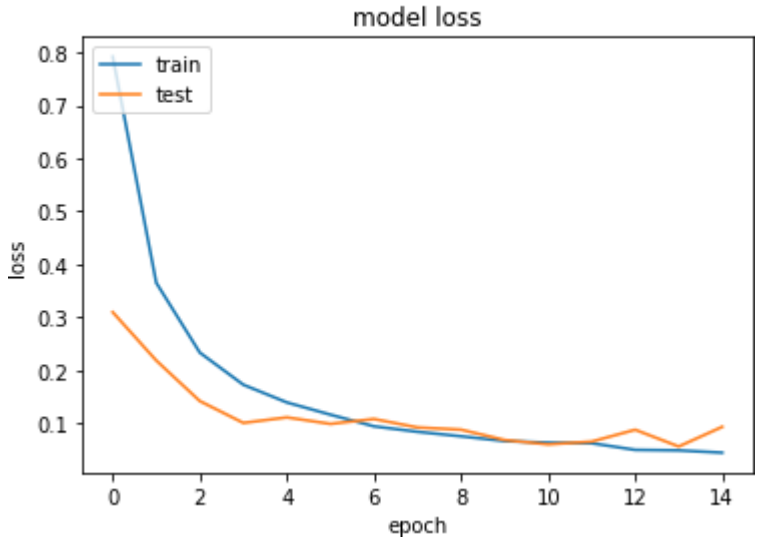

Fig-12: convolution neural network loss

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Table 3.Comparison between different networks

TECHINIQUE	PREDICTION	ACCURACY
Neural Network	8103 images Predicted	86%
Deep Neural Network	8880 images Predicted	93%
Convolution Neural Network	9233 images predicted	97%

CONCLUSION AND FUTRUE WORK

With help of Deep Learning Techniques, Fruit images were classified and as a result 9672 images were tested in that 9233 images predicted correctly.

Performance evaluation has been done by comparing different neural network techniques like, Normal Neural Network, Deep neural network, and CNN.At the end CNN has best accuracy of about 97% for the fruit image classification. In the fruit image classification. In future, each fruits calories were decided to calculate.

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