

# Autonomous Fruit Recognition System Based on Deep Convolutional Neural Network



Sahana P. Savant, P.S. Khanagoudar

**Abstract:** Recently it is found that people are becoming more cautious to their diet throughout the universe. Unhealthy diet can cause many problems like sugar, obesity, gain in weight and many other chronic health related issues. Essential part of our diet is contributed by fruits as they are rich source of vitamins, fiber, energy and nutrients. Today's era has been adapted to a system of intake of foods which has several adverse effects on human health. The proposed system is Autonomous Fruit Recognition system based on Deep Convolutional Neural Network (DCNN) method. Using this technology recognition and estimation of fruit calories is necessary to spread awareness about food habits among people suffering from obesity due to bad food culture and consumption of food. This proposed web/app based system simplifies the calorie measuring process of fruit. The machine learning based API used in our system recognize the fruit and provide calorie content of that fruit. System uses convolutional Neural Network called MobileNet. This web/app based application is user friendly.

**Keywords:** Fruit Recognition/ DCNN/ Machine vision/Calorie measurement/MobileNet

## I. INTRODUCTION

One of the serious condition our Country is facing today is obesity. Rates of overweight and obesity have grown to epidemic outbreak which threaten India's economic conditions and security over past few years. The common method for estimation of human weight is done by (BMI)Body Mass Index[1]. Based on persons height in meters and weight of a person in kilograms BMI is calculated. When a BMI of a person is greater than or equivalent to 30 kg/m<sup>2</sup> person said to be obese [2]. Over the period of few years the number of obese person is increasing in rapid rate[3]. The main Reason for fatness and excess weight in beginning level is nutrition imbalance and excess calorie intake. Consumption of healthy nutritious food improves health and minimizes nutrition related epidemics diseases and overweight. In Obese people generally we find Chronic diseases such as diabetes, hypertension, breathing disorder, myocardial infarction, stroke [4]. The most common reason for excess weight of a person is more consumption of food as compared to energy consumed. So daily food intake must be regularly measured to reduce weight in a systematic

way and to control healthy weight[5]. Novel smart phone shall be used for estimation of calories incase of normal human beings to monitor weight and to boost good health of patients suffering from diabetes. Due to current trends and advancement of technology mobile devices such as health monitoring smart applications such as mobile devices are accessible to patients all the time. The mobile application which measures food intake automatically can be used to estimate the consumption of calories of patients[6].

Electronic devices plays an crucial role for recognition of food such as mobile phones. The present approaches of current control of diets is based on fixed and flexible background information in getting food images. The web/mobile based system is useful to common people for proper intake of food. The rest of the paper consists of following sections, Section I introduces the topic, Section II relates to survey of Literature, Section III focuses on Proposed system, section IV is Conclusion and the final section involves the References.

## II. LITERATURE REVIEW

There are two approaches in nutritional therapy i.e Ancient and Computerized approaches. Usage of the Ancient methods is popular for many years in hospitals and research studies. Computerized methods are recently used throughout the globe. In this paper, we are focusing on different methods of common dietary control measures and demerits of those methods are proposed. This can be used for medical purpose and to introduce novel treatment methods of people suffering from fatness and excess weight. For measuring food system following are the different methods. M. Livingstone et al. [7] uses this approaches In Clinical Approaches method that is 24 hr dietary recall which, basically means an interview and F.E. Thompson et al.[8] food frequency questionnaire (FFQ). In this 24 hr dietary recall people shall be asked to keep record of food and drink intake during past 24 hrs. Trained interviewer is required for this. The interview can occur online through mobile device or meeting the patient face to face. The interviewer should have knowledge regarding cooking methods and nutritional knowledge to control and complete data collection format This method is not so useful because it needs only a little memory and trained interviewer. This method is inconvenient for specially obese people. In 24 hrs dietary recall reporting may be inaccurate due to number of factors like age, education, gender etc. The limitations of clinical approaches can be overcome by Assistant-based approaches such as electronic devices. They are used nowadays for calorie measurement like mobile devices. People use electronic devices like mobile phones as a User Interface and forward their information to expert.

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Then expert will measure quantum of food. In this Assistive technique, initially captured image is sent to the server and analysis is done manually. Based on the food and Nutrient Database for Dietary Studies(FNDDS) extraction of nutritional information of the food is the next step. Finally result is sent back to the user for further confirmation and/or adjusting this information. Main Demerit of this Assistive method is that results are delayed[19]. Fruits are one of the healthy diet option.They contain less sodium,fat and calories.But they are abundant in fiber potassium and vitamin C. A diet rich in fruits can help us to fight against cancer, diabetes, heart diseases etc. A system is needed which will help us to know how much calories particular diet or fruit intake contains that can be very useful to maintain healthy diet without expert advice . Along with health benefits, eating fruits can make weight management easier. Fruit recognition based on object intensity, colour, texture is recognized by computer vision. S.Arivazhagan et al. [9] discusses fruit recognition based on efficient fusion of various features of the fruit,and with the help of minimum distance classifier, which is further based upon the co-occurrence and statistical features derived from the Wavelet transformed sub- bands. Horea Muresan et al. [10] discusses on how to increase the accuracy of the neural network,360 dataset is introduced and tensorflow is used as a framework .In this paper new high quality dataset of fruits is introduced.Complex and new database of images with fruits is introduced .Future scope of this paper is mobile application which takes picture of fruits. Another objective of this paper in future is to expand the dataset which include more fruits.It also discusses on an effective system of fruit classification using deep convolutional neural network model is proposed. Israr Hussain, et al.[11] discusses about Deep Convolutional Neural Network with the help of data expansion techniques and further application of deep convolutional Neural Network. Fruit images of 15 class varieties are taken. Without the intervention of any feature extraction Image can be used as a input in Deep Convolution neural network ( DCNN) Model with only five-layers, is proposed, to improve recognition performance Hasan Basri et al. [22] Faster R-CNN to detect Classification of multi fruits is proposed in this paper Distinguishing of convolutional neural network is done deeply using MobileNet's. Mango and Pitaya fruits are taken as a input . The realtime dataset is taken in the study. MobileNet model is used on TensorFlow platform. The accuracy score of about 99% is obtained.To build efficient model,training is done quickly and classification of fruits is done based on the width multiplier along with checking the rightness level, shrink size and latency. For this Faster RCNN is used.

### III. PROPOSED SYSTEM

The proposed web/app based system simplifies the calorie measuring process of fruit. The user has to take the picture of the fruit by clicking on capture image button or browse for the fruit image. After taking the picture of fruit, the preview of the picture appears in our web/mobile application, Then we need to click on detect button or on reset button to reset. Then the machine learning based API used in our system recognize the fruit and provide the calorie content of that fruit. Our system uses a CNN (convolutional neural network) called MobileNet.

## IV. METHODOLOGY

### System Architecture

#### TRAINING PHASE

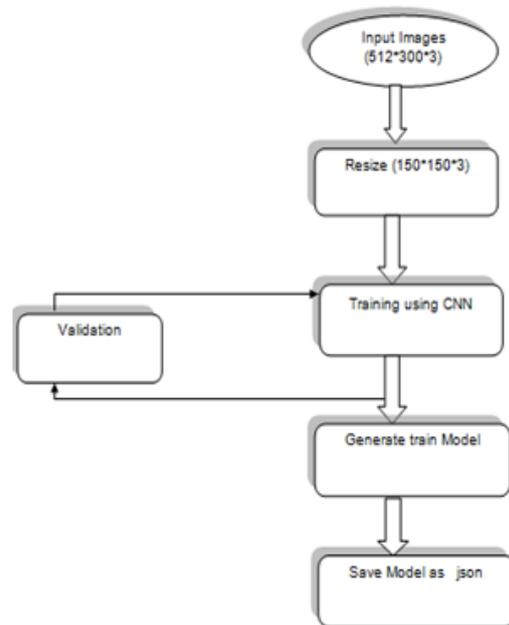


Figure 1: Training Phase

#### TESTING PHASE

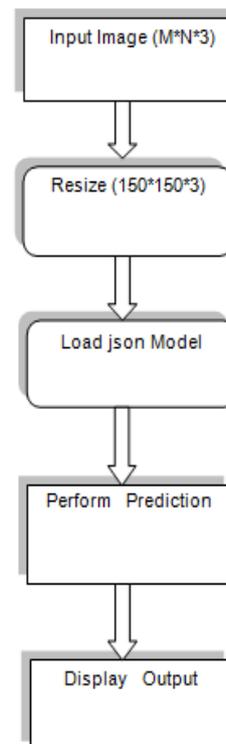


Figure 2: Testing Phase

The procedure used in this scheme involves:

1. Images of fruits are selected

2. Images of all fruits are resized
3. Convert all resized Red Green Blue images into Gray Scale
4. Convert the (n,width,height ) of dataset into (n, depth, width, height)
5. Divide dataset into training,test ,validation set.
6. Data type is converted to float32 and normalization of data values is done from 0-255 to the range [0,1]
7. class labels are preprocessed
8. Create own training method
9. Define our model architecture
10. Compile the model
11. Training data for certain iterations
12. Evaluate model on our test dataset
13. Classification has been done through Tensor flow
14. Calorie Estimation.

## V. TECHNIQUES

### A. Deep Learning

Deep Learning is evolved from Machine learning Deep Learning enables machines to take decisions with the help of Neural Network. It needs a large amount of training data and needs high end system to work. Machine learns the features from data. The problem is solved in an end to end manner. Testing takes less time and is more accurate. Deep Learning is inspired by human brain structure .In Deep Learning features are picked by neural networks without human intervention so high volume of data can be trained. There will be input layer after that process happens it goes to hidden layer every node is interconnected. After hidden layer 1 it goes to hidden layer 2. Then it goes to output and compares with input There will multiple hidden layers In deep learning. Some of the examples of Deep learning is in customer support,medical care,self driving cars etc.

#### Why Do we need Deep Learning?

- Deep Learning can process large amount of unstructured and structured data
- Complex operations can be performed in Deep Learning.
- High performance of huge data can be increased
- Extraction of feature can be done in this type of learning
- Training Time is more.

#### Problem Before Neural Network came into existence

Earlier traditional computers used algorithmic approach where the computers used to follow set of tasks and unless specific sets where known and understood by computers ,computer couldnt solve a complex problem . so during that times we needed a person who would help to solve the problem .He/she can solve tasks/instructions and help computer to solve the problem .This would restrict usage of traditional computers, but what about problems whose answers we had no idea. So that is where Neural Network were introduced

### B. Neural Network

Neural Networks consist of units called neurons which is inspired by visual cortex of human brain. Neurons are grouped into multiple layers of which one layer Interact with other.

#### Types of Neural Networks

- i. Artificial Neural Network

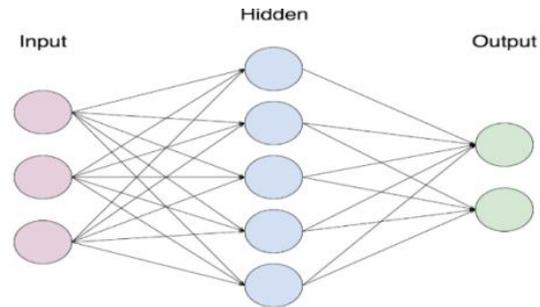


Figure 3 : layers of Artificial Neural Network

Figure 3 shows layers of Artificial Neural Network .Artificial Neural Network is lower layer of Machine Learning. There is Input ,Hidden and output layer as shown in the figure One of biggest demerit of Artificial Neural Network is that it has less hidden layers and slower when compared to Convolution Neural Network .So we go with Convolution Neural Network as it has many hidden layers and it is faster

#### ii. Convolutional Neural Network

It is feedforward Neural Network that is used to analyze the image .In CNN every picture is represented in the form of pixel values .It is deep Learning algorithm which has bias and weights. Convolutional Neural Network are used in recognition of patterns in images which is the only difference when compared to a Artificial Neural Network .The structure of Convolution Neural Network is similar to visual cortex of human brain. Processes involved in the training of any neural network are of two types

1. Forward Propagation: Receive input data, process the information, and generate output
2. Propagation: Calculate error and update the parameters of the network.

Here are simply a few well-known laptop computer resourceful and prescient functions the region CNNs are used:

- Facial focal point systems
- Analyzing and parsing through documents
- Smart cities (traffic cameras, for example)
- Recommendation systems, among one of a kind use instances.

#### ➤ Input Image

In the below figure we can see Red, Green Blue image which can be viewed as three different images red scale, green scale and blue scale image which are stacked on top of each other. Convolutional Neural Network has its role in reducing the images into a form which are easier to process without losing features and this helps in getting a good prediction. It is scalable to datasets which are large.



Figure 4: 4x4x3 RGB Image

# Autonomous Fruit Recognition System Based on Deep Convolutional Neural Network

Operations in Convolutional Neural Networks are of four types as shown in figure 8

- Convolution layer
- Activation
- Pooling layer
- Fully Connected Layer

## ➤ Convolution layer

Convolution layer is sometimes called as kernel or filter. It is made to pass over an image. Viewing few pixels at particular time (Eg: 3\*3 or 5\*5). It is the weights defined in the filter and dot product of the original pixel values. In the below demonstration 5x5x1 where pixel values are 0 and 1 and the kernel is 3x3x1

The kernel or a filter performs a matrix multiplication every time it shifts. It shifts 9 times because of stride length=1. This multiplication operation is between k and portion p of the image. Filter moves with certain stride value till it passes over the complete width and repeats the process till the entire image has been traversed. When the stride value is 1 we pass the filter one pixel at a time

The first layer of convolution performs low level operations or features such as detection of edge, colour, sharpen, gradient orientation, blur with added layers like operations which are high level which helps giving wholesome understanding of input images can be made out.

Consider the below input image



In the Figure 5 results of convolution of above input with filters can be seen. We can function operations such as detection of edge, blur and sharpen simply altering the values of matrix filter as shown below

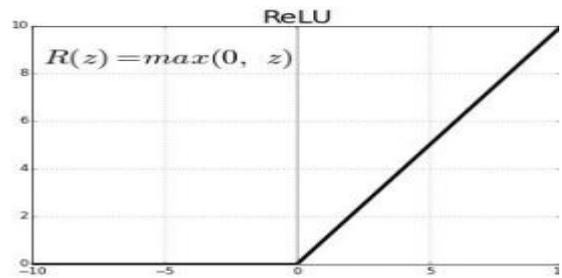
Operation	Filter	Convolved Image
Identity	$\begin{bmatrix} 0 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 0 \end{bmatrix}$	
Edge detection	$\begin{bmatrix} 1 & 0 & -1 \\ 0 & 0 & 0 \\ -1 & 0 & 1 \end{bmatrix}$	
	$\begin{bmatrix} 0 & 1 & 0 \\ 1 & -4 & 1 \\ 0 & 1 & 0 \end{bmatrix}$	
	$\begin{bmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{bmatrix}$	
Sharpen	$\begin{bmatrix} 0 & -1 & 0 \\ -1 & 5 & -1 \\ 0 & -1 & 0 \end{bmatrix}$	
Box blur (normalized)	$\frac{1}{9} \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$	
Gaussian blur (approximation)	$\frac{1}{16} \begin{bmatrix} 1 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 1 \end{bmatrix}$	

Figure 5: Effects of different convolution matrix

## ➤ Activation layer (RELU)

RELU stands for Rectified linear unit and it is a type of activation function it is defined mathematically as

$R(Z) = \max(0, Z)$  as shown below. This convolutional layer generates a matrix and this matrix is run through an activation layer which introduces non-linearity to allow the network to train itself via back propagation.



## ➤ Pooling layer

It is the process lowering the dimensions of matrix and down sampling. It helps in reducing computational power which is needed for processing of data. These two types of pooling are Average pooling and Max pooling

Max pooling: It is maximum value from the picture covered by kernel. The main use of Max Pooling is Suppressant of Noise. It extracts features like edges. On the different hand, Average Pooling extracts features smoothly. Average pooling: It is Average of all values from the portion of image which is covered by kernel.

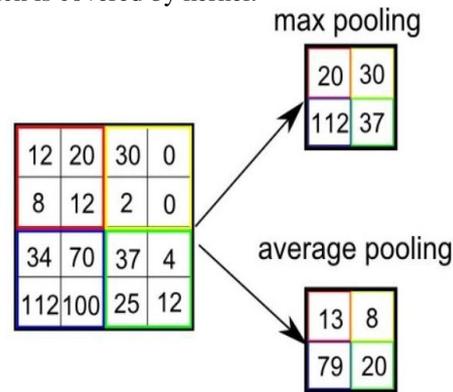


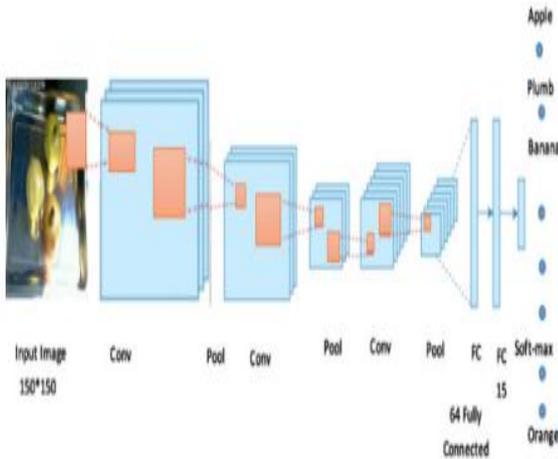
Figure 6: shows MAX pooling and MIN pooling

## ➤ Fully Connected layer

It takes the output of previous layer. The input of fully connected layer is 1 dimensional vector. It takes the output of previous layer and flattens them into single vector. Figure: 7 shows many convolution and Relu operations.

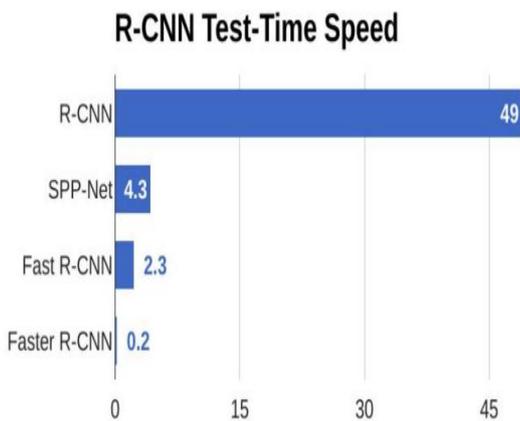


Figure 7: shows many convolution and Relu operations

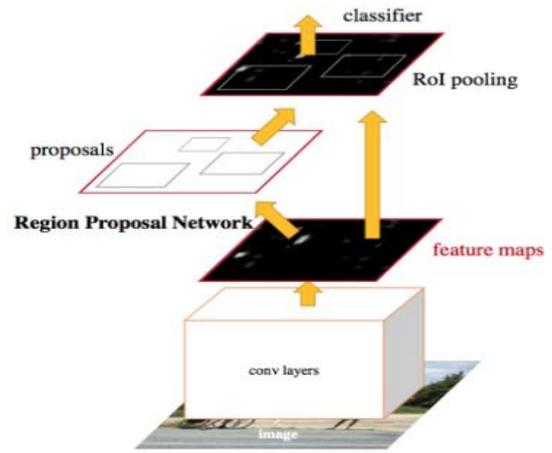


**Figure 8: Operations in Convolutional Neural Networks**  
 • Why Faster Region Convolutional Neural Network is used?

Algorithms like fast Region Convolutional Neural Network and Region Neural Network selective search algorithm is used for determining region proposals. The algorithm that is used in Region convolutional Neural Network and fast Region convolutional Neural Network is time consuming and process is slow. Performance of network is affected. So Shaoqing Ren et al founded algorithm which helps in object detection that helps in elimination of selection search algorithm and it lets the network learn proposals of region. Similar to other algorithms in fast Region Convolutional neural network image is sent as a input to convolutional network which helps in providing a convolutional feature map for identification of region proposal. The Region proposals which are predicted with the help of ROI pooling. Layer is reshaped which helps in classification of images within the region proposed. Figure 9 Test-time speed of object detection algorithms are compared. Figure 10 shows layers of RCNN



**Figure 9: Test-time speed of object detection algorithms are compared**



**Figure 10: shows layers of RCNN**

The main support of this web-based application is Mean Stack

- MEAN stands for
  - MongoDB
  - Express.js
  - AngularJS
  - Node.js

Figure 11: shows representation of layers of MEAN STACK

▪ **AngularJS:**

It is the front end development and freely available online. Angular 7 is used in our project. It is responsive i.e. it can run on both desktop and mobile applications. In angular JS every app is a component.

There are four types of components like html, css, spec and its component. It has Model View Controller framework. It is used for prediction and classification of food images. Angular JS was developed by Misko Hevery in 2009. By studying Hypertext markup language (HTML) page, AngularJS framework can be known, HTML attributes are embedded into it..

AngularJS is updated by google team which has high speed ,good performance,complete framework for javascript .Testing and animation can be done using AngularJs.

▪ **Tensorflow.js**

It includes a feature of that defines, optimizes and calculates mathematical expressions easily with the assist of multi-dimensional arrays known as tensors. It includes a programming aid of deep neural networks and laptop gaining knowledge of techniques. It consists of a excessive scalable function of computation with a variety of data sets. TensorFlow makes use of GPU computing, automating management. It additionally consists of a unique function of optimization of same reminiscence and the facts used.

Why is TensorFlow So Popular?

TensorFlow is well-documented and consists of masses of laptop gaining knowledge of libraries. It affords a few vital functionalities and techniques for the same.

TensorFlow is also known as a “Google” product. It includes a variety of machine getting to know and deep gaining knowledge of algorithms. TensorFlow can educate and run deep neural networks for handwritten digit classification, photo recognition, word embedding and creation of various sequence models.

▪ **Node.js**

# Autonomous Fruit Recognition System Based on Deep Convolutional Neural Network

It is freely available online. The environment which is used to build node is runtime like Application Programming Interface .Web app running on web and mobile app running on mobile device interact with backened services. For building scalable code Node.js is used. It is framework which is web based build on Google Chrome .It has systems which are distributed, event driven and asynchronous.It is very fast Node and Node Package Manager is used for effective management of package.There is no buffer in application.It is used to build backened services.Companies like Paypal,Netflix etc uses this Node.js

## ▪ Express.js

**Express.js** is the server side scripting language. It is faster application development framework.It has multi and single page application. Integration to database is done easily using Express.js.It is build on top of Node.js.Configuration of Express.js is done easily and it has less code and helps in handling errors,defines middleware etc.

## ▪ MongoDB:

Real Time Atlas MongoDB is used .Eliot created MongoDB in 2007 because there was issues' related to relational databases. It is database which is non relational. MongoDB is an freely available online.It stores data in a database.It has large amounts of data storage capacity. Enables to build faster applications and performance is good.

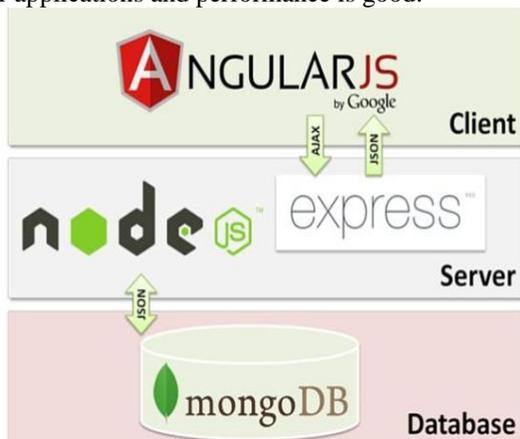


Figure 11: Representation of layers of MEAN STACK

## ▪ MobileNet Model

MobileNet is the model which is suitable for embedded application and mobile devices.This model was proposed by Google. They can be used for, detection, classification, embeddings and segmentation similar to how other popular large scale models, such as Inception, are used.MobileNet are low latency , low-power,parameterized and low power models to meet the resource constraints of a variety of use cases. MobileNet v2 model is used in our project .53 layers deep are present in MobileNet v2 model and it is a Convolutional Neural Network .The network is trained on many images from the database Imagenet. Network which is pre trained can classify images into 1000 object categories, such as pen, birds,fruits etc. MobileNet-v2 is faster in mobile devices compared to MobileNet- v1.Tensorflow provides ImageNet while CocoSSD is minor version of Mobilenet.

## ▪ CocoSSD

It is a Deep learning mobile net v2 model. Objects in this model are detected which is defined in coco dataset,which is used in detection of objects ,captioning and segmentation. Detection of 90 classes of objects is done by this model. Single Shot Multibox Detection is faster than Region based Convolution Neural Network Bounding boxes prediction is

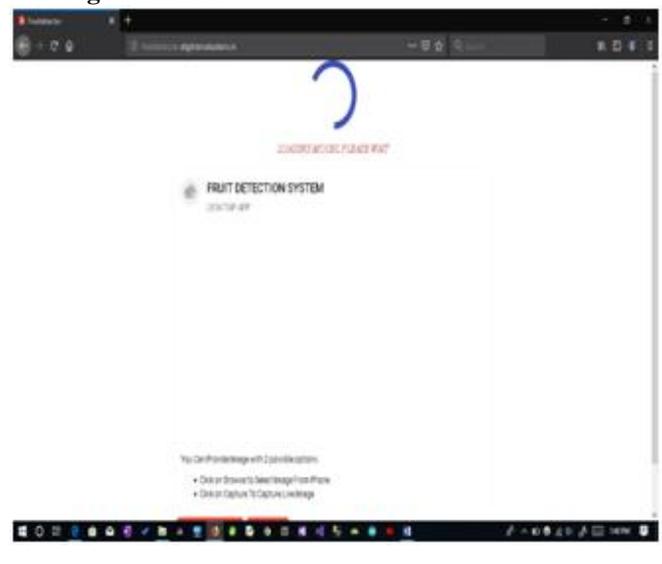
done by single shot multibox Detection after many convolutional layers ,in order to handle the scale .Since each of the convolutional layer operates at a different scale, it is able to detect objects of various scales.



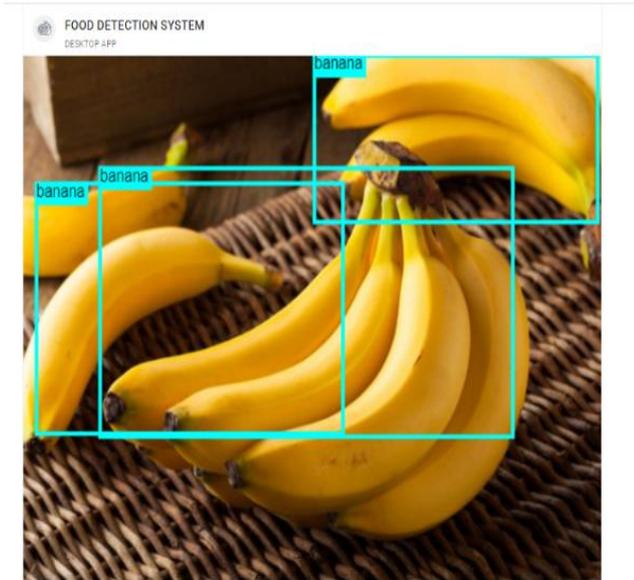
Figure 12 Recognition tasks can be done using MobileNet as shown in figure

## VI. RESULTS

### Loading the model



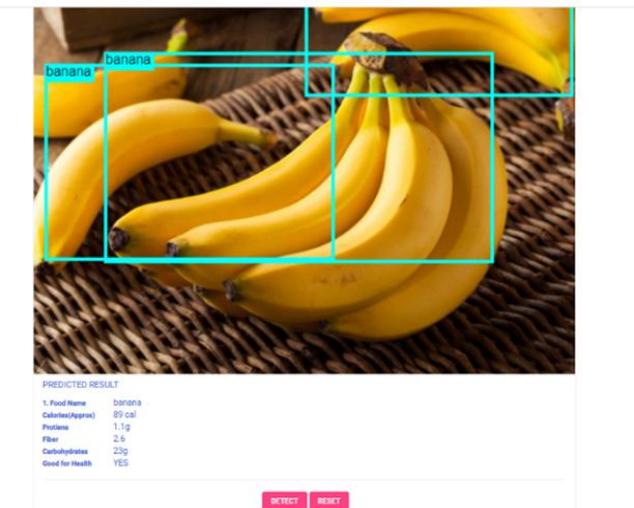
After selecting the food image



Food image detected



After loading the model



Calorie calculated



Browse for the food image

MOBILE INTERFACE

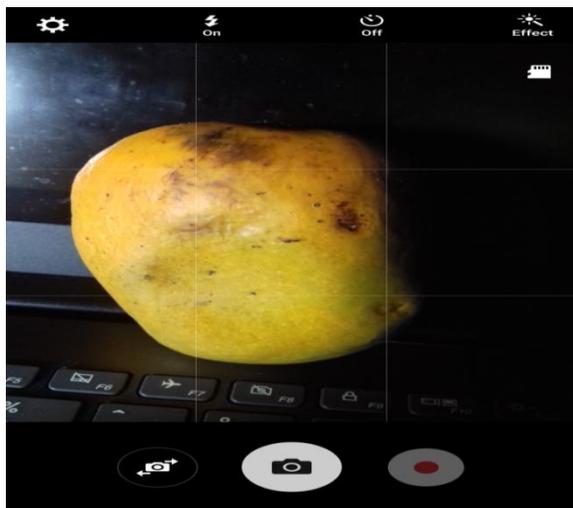
Loading the model



# Autonomous Fruit Recognition System Based on Deep Convolutional Neural Network



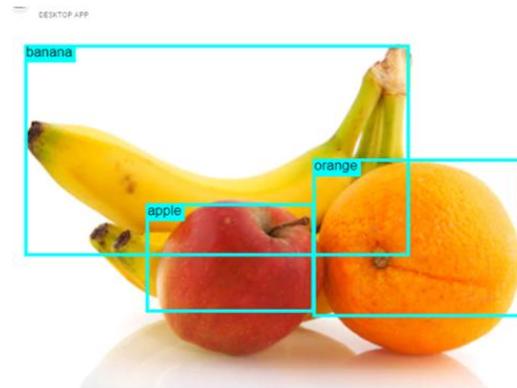
Food image detected



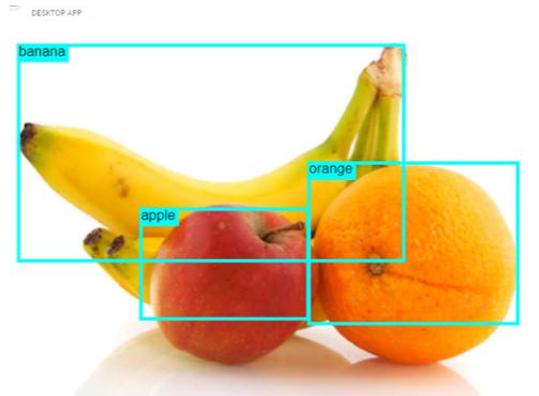
Food image capturing  
Multiple fruits taken Simultaneously



After selecting the food image



Food Image Detected



## PREDICTED RESULT

1. Food Name orange  
Calories(Approx) 47 cal  
Protiens 0.9 g  
Fiber 24g  
Carbohydrates 12g  
Good for Health YES

2. Food Name banana  
Calories(Approx) 89 cal  
Protiens 1.1g  
Fiber 2.6  
Carbohydrates 23g  
Good for Health YES

3. Food Name apple  
Calories(Approx) 52 cal  
Protiens 0.3g  
Fiber 2.4g  
Carbohydrates 14g  
Good for Health YES

DETECT RESET

Calorie calculated



**Datasets Taken In Our Project**

**VII. CONCLUSION**

The proposed web/app based system simplifies the calorie measuring process of fruit. The user has to take the picture of the fruit by clicking on capture image button or browse for the fruit image. After taking the picture of fruit, the preview of the picture appears in our web/mobile application, Then we need to click on detect button or on reset button to reset. Then the machine learning based API used in our system recognize the fruit and provide the calorie content of that fruit. Our system uses a CNN (convolutional neural network) called MobileNet.

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