Fruit Classification and Calories Measurement using Machine Learning and Deep Learning

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Abstract - *It is imperative to take great measures of calories to stay away from different illnesses. The Standard admission of various calories is basic for keeping the correct equilibrium of calories in the human body. In this paper, a web-based application for estimating fruit calories and improving individual's utilization propensities for wellness is developed. A calorie portion of a fruit is distinguished utilizing standard picture dataset utilizing various advances such as pre-processing, segmentation, feature extraction, training and classification using shape and size with the help of machine learning techniques. fruit object dimensions are determined using image processing techniques. The final step is to estimate the calories in the given fruit and provide the users, patients with optimum solutions for fruit intake. The analysis of different calorie estimation techniques is presented.*

Key Words*: *Object Detection, Convolution Neural Network, Deep Learning, Image Recognition, Image Segmentation, Data Augmentation

1.INTRODUCTION

In the entire world, individuals are getting more worried about their weight, in order to stay away from stoutness by consuming healthy and low-calorie food, thus a reliable system with high accuracy and efficiency for calorie and nutrition sustenance estimation in fruits needs to be created. Obesity treatment requires the patient to record the measure of the day-by-day food burned-through, yet truly, it isn't that simple for the patients to evaluate or direct their everyday consumption because of components like lack of nutrition, education or self-control. The proposed model is developed to help dieticians and patients to know about their daily admission of calories.

2. LITERATURE SURVEY

A. Health Monitoring Application: Epuru Sai Muralidhar et al. [1] proposes a faster R CNN-based food classification and food detection model using TensorFlow to estimate the number of calories. One of the Classification Algorithms, a random forest algorithm is utilized to analyse and detect the data in the frame to decide the nourishment's form.

B. Calories Measurement: An estimation strategy is made that approximates the quantity of calories from an image by enrolling the volume of the fruit or vegetable from the image and utilizing nourishment facts tables to figure out the calorie count in leafy foods. Manisha Mittal et al.[2] believes that this technique is nonexclusive in nature and they applied this model to various kinds of foods grown from the ground.

C. Fruit Detection: A methodology for robotic fruit identification utilizing image processing has been exhibited. Pavan Kunchur et al. in [3] consolidates three stages: pre-processing stage, feature extraction stage, and testing stage. FE is carried out utilizing the accompanying strategy; the primary estimation tone and shape and computation delivers the component vector color parameters (i.e., skewness, variance, and its mean) and shape (Euler Number, Eccentricity, and Centroid,). The second calculation was done using SIFT. KNN classifiers can be used to perform classification operations.

D. Supplementary Nutrition Value: In this paper, Anita Chaudhari et al.[4] portrayed the advancement of an Object detection system using CNN, which runs on mobile devices. They've raised a Fruit image dataset from capturing multiple images of a particular fruit, applied Convolutional Neural Network to the identification of 20 fruit objects, and calculated its presentation.

E. Food Recognition for Calorie Measurement: In this paper, Ankita A. Podutwar et al. [5] put forth a measurement method that estimates the amount of calories and Nutrition from a food image by estimating the food parcels utilizing skull stripping to quantify the measure of calorie and sustenance in the food and if Calorie or Nutrition one of the boundaries is high in the picture then it will show that it is an energies food assuming not, low energies food.

F. Calorie Measurement from Food Image: S Anushadevi in [6] incorporates a measurement method that gauges the quantity of calories from a food's image by measuring the volume of the food and utilizing dietary realities tables to quantify the measure of calorie and nourishment. This system is designed to identify food items in an image using image processing and segmentation, food classification using SVM, food portion volume measurement, and calorie measurement based on food portion mass and nutritional tables.

G. Automatic fruit classification: Hossam M. Zawbaa et al. [7] has presented machine learning techniques for automatic fruit classification. The classification is done using the Random Forest (RF) algorithm. The Random Forest (RF) algorithm result is compared with K-Nearest Neighborhood (K-NN) and Support Vector Machine (SVM) algorithms. For orange the height accuracy is achieved (100%) with SIFT feature extraction and KNN classifier. The height precision accomplished in the subsequent gathering is for 96.97% apple (with RF classifier), and for 78.89% orange (with SVM classifier).

H. Fruit Recognition System: In this paper, Vishnu H S et al. [9] put forth a measurement method that identifies the fruit class using CNN and also estimates number of calories from an image by using color segmentation, k-mean clustering methods. The user input image is captured by the raspberry pi through the webcam for recognition.

2.1 Summary of Related Work:

The summary of methods used in literature is given in Table 1 and Table 2.

Table 1: Features and techniques used for calories estimation in fruits by authors in literature

Paper	Feature	Technique	Accuracy
Hossam M. Zawbaa et al. 2014 [7]	Shape, Color	RF,SVM, KNN	96.97% 78.89% 92.31%
S. Anushadevi 2015 [6]	Size. Shape, Color, Texture	K-Means, SVM	90.41%
Ankita A. Podutwar et al.2017 [5]	Shape, Color	SVM, Fuzzy C-Means	89%
Anita Chaudhari et al. 2019 [4]	Shape, Color, Texture	CNN	80%
Pavan Kunchur et al. 2019[3]	Shape Color	KNN	80%
Manisha Mittal et al. 2019 [2]	Color, Size, Shape,Texture	SVM,RF, KNN, DT	88%
Epuru Sai Muralidhar et al. 2020 [1]	Shape	Fast R-CNN	92%

Table 2: Summary of Classifiers used in literature

Paper	ML techniques				
	SVM	KNN	CNN	RF	DT
Hossam M. Zawbaa et al. 2014 [7]	Yes	Yes		Yes	
S. Anushadevi 2015 [6]	Yes				
Ankita A. Podutwar et al.2017 [5]	Yes				
Anita Chaudhari et al. 2019 [4]			Yes		
Pavan Kunchur et al. 2019 [3]		Yes			
Manisha Mittal et al. 2019 [2]	Yes	Yes		Yes	Yes
Epuru Sai Muralidhar et al. 2020 [1]			Yes	Yes	

3. METHODOLOGY

To accomplish better area results, we will utilize a Deep Learning strategy called Convolutional Neural Network to improve the accuracy.

3.1 System Architecture

The system architecture is given in Fig. 1 also each block and their implementation are described in this Section.

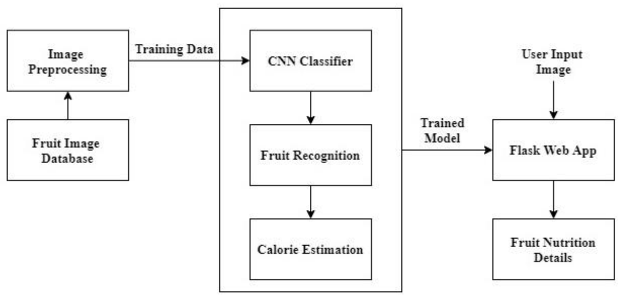

Fig 1: Block Diagram

A. Image Preprocessing: To perceive organic products just as calories from food in the image, a type of training information is required. In this thesis, three distinctive datasets have been utilized where two of them are freely accessible and the last one is a recently made mix of past two datasets as demonstrated in Table 3. For our project we selected five different types of fruit classes.

Table 3: Dataset statistics used in the implementation of fruit classification

Dataset	Size	#Images	Classes	Labeling
Fruits 360	758.4 MB	90483	131	Already labeled

Object Detection	29.72 MB	900	15	Already labeled
Fruit 123 (Customize)	46.72 MB	3640	5	Already labeled

CNN requires lots of training data to learn features automatically. In order to increase the size of data sample different image preprocessing and augmentation techniques are used. Keras ImageDataGenerator class is used to create a number of random transformations, which helps to increase the size of the data sample when it is needed. Data samples created using image augmentation techniques generally increases the existing data by the rate of nearly 3x to 4x times. Image preprocessing parameters like Rotation, Width shift, Height shift, Horizontal flip, Zooming have been used to increase the size of the training dataset. Fig. 2 Shows one example of such preprocessing operation on data.

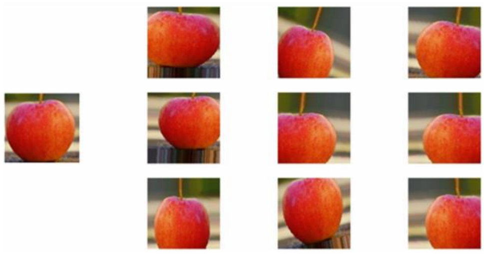

Fig 2: The raw image (left) and expanded images (right)

B. Neural Network Model: The base of the model being made is deep learning and the technique used is convolution neural networks (CNN), the model is being developed as shown in Fig. 3. CNN also called ConvNet is a class of deep neural networks which is based on shared-weights architecture and translation invariance characteristics.

Model Building & Training: The model currently takes the information and cycles it further the network. Our CNN has four convolutional layers with the 16,32,64,128 filters each. For each layer, we added the ReLU activation function and used the max operation for pooling to reduce the spatial dimensions and added a dropout layer to reduce the chances of overfitting. For the completely associated layers softmax enactment work is utilized, which is explicitly utilized for multilabel classification. The end layer of the model is a dense layer of 5 nodes as we have 5 types of fruit which uses Softmax function' which gives the probabilities of the type of fruit in the Image.
The Sequential CNN model is incorporated with an adam analyzer. We ran our model with 30 epochs, with batch sizes of 32.

```
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d (Conv2D)              (None, 64, 64, 16)        448
_________________________________________________________________
activation (Activation)      (None, 64, 64, 16)        0
_________________________________________________________________
max_pooling2d (MaxPooling2D) (None, 32, 32, 16)        0
_________________________________________________________________
conv2d_1 (Conv2D)            (None, 32, 32, 32)        4640
_________________________________________________________________
max_pooling2d_1 (MaxPooling2 (None, 16, 16, 32)        0
_________________________________________________________________
conv2d_2 (Conv2D)            (None, 16, 16, 64)        18496
_________________________________________________________________
max_pooling2d_2 (MaxPooling2 (None, 8, 8, 64)          0
_________________________________________________________________
conv2d_3 (Conv2D)            (None, 8, 8, 128)         73856
_________________________________________________________________
max_pooling2d_3 (MaxPooling2 (None, 4, 4, 128)         0
_________________________________________________________________
dropout (Dropout)            (None, 4, 4, 128)         0
_________________________________________________________________
flatten (Flatten)            (None, 2048)              0
_________________________________________________________________
dense (Dense)                (None, 128)               262272
_________________________________________________________________
batch_normalization (BatchNo (None, 128)               512
_________________________________________________________________
dropout_1 (Dropout)          (None, 128)               0
_________________________________________________________________
dense_1 (Dense)              (None, 5)                 645
=================================================================
Total params: 360,869
Trainable params: 360,613
Non-trainable params: 256
```

Fig 3: CNN Model implemented for fruit classification

C. Fruit Segmentation: The fruit item is distinguished with the assistance of the CNN model. In the subsequent stage, we do image segmentation with the assistance of morphological functions of OpenCV. A combination of techniques including canny edge detection and morphological operators are utilized to segment the fruit item to obtain the contour of the fruit as shown in Fig. 4.
A mixture of techniques like canny edge detection and morphological operators like dilation were used to segment the food item to obtain the contour of the fruit. A Contour based segmentation is done by calculating the number of contours and by finding the biggest fruit contour. For different foods different sets of morphological operations need to be performed multiple times in order to get the food region.

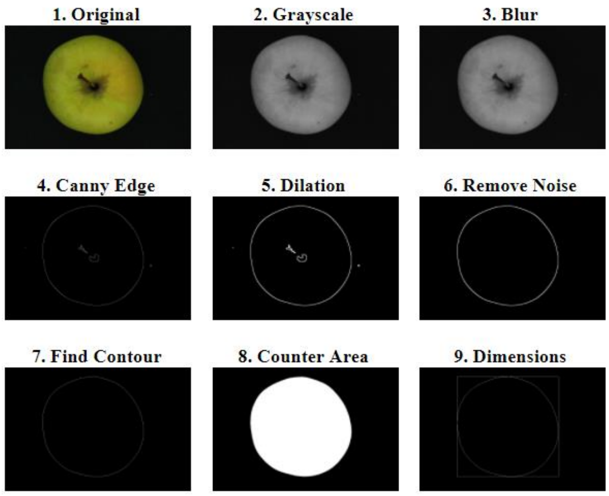

Fig 4: Segmentation and contour detection processes

D. Calorie Estimation: Once an area of the detected fruit has been found, the volume is calculated primarily based on distinctive shapes of the fruit. In our case we've used an apple. First Radius is obtained by dividing it with pi (3.14). Then volume of sphere is obtained using the formula,

*Volume of sphere = (4/3)*pi*radius*radius (1)*

Volumes of other fruit shapes like cylinder (banana) and ellipsoid (pear, mango) can be found by utilizing the suitable volume formula. The implemented system relies on this table as a reference to measure nutritional facts from any selected fruit photo as shown in Table 4.

Table 4: Fruit Nutritional Information

Fruits	Density (g/cm3)	Calorie	Shape	Label
Apple	0.609	52	Sphere	1
Banana	0.94	89	Cylinder	2
Mango	0.7	60	Sphere	3
Orange	0.482	47	Sphere	4
Pear	0.52	57	Sphere	5

By utilizing the density values and the calculated volume value, the mass of the fruit has been acquainted. By considering the value of 100 grams of food, the total calories of the fruit have been determined.

*Estimated Weight = Actual Density * Estimated Volume (2)*

*Estimated Calories = (Estimated Weight * Calories per 100gm)/100 (3)*

E. Input Image: Image uploaded by the user is used as an input image.

F. Output: The trained model is deployed on flask web app which identifies fruit class of input image and gives calorie count in text format.

4. RESULTS

A simple flask-based application is created for calorie detection so any patient can monitor their daily intake of nutrition.

Fig 5 shows Calories and nutrition results for orange class. Input images are passed through a progression of put images are passed through a series of image segmentation operations to ascertain calories.

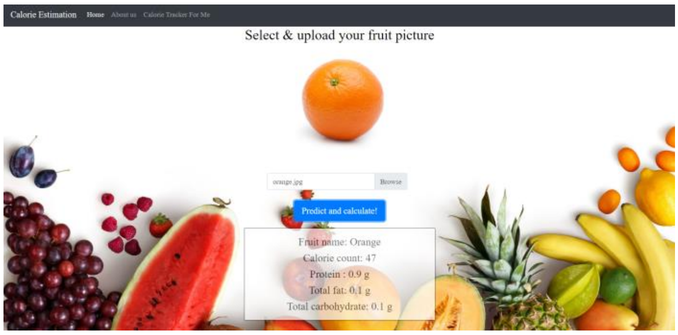

Fig 5: Calorie Result for Orange

Fig 6 shows a random sample of test images with their predicted fruit labels. Correctly predicted fruits are shown with green labels and incorrectly predicted with red labels.

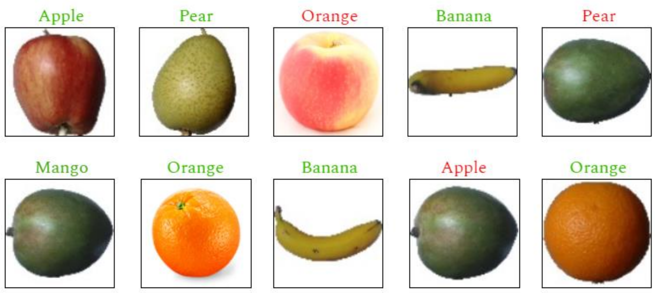

Fig 6: CNN Fruit Prediction Sample Output

A five-layer CNN model was developed to accomplish the best test accuracy of 74%. The CNN model however experienced perceivable overfitting because of limited training data. This issue was addressed by expanding the training data through various affine transformations, which also considerably increased the overall test accuracy to more than 90% as shown in Table 5.

According to the accuracy and loss curves, it seemed that the CNN model could be further improved by increasing the training epochs. Hence, another three training schemes with 30, 100 and 200 epochs respectively were implemented. Fig 7, Fig 8 and Fig 9 show their accuracy and loss curves. The test accuracy did increase further, but not by a large margin. After 100 epochs the training accuracy started to exceed the test accuracy and the gaps between training and test tended to enlarge. while training 200 epochs only increased the training accuracy, but not the test accuracy which seemed to level off around 95% as shown in Table 5.

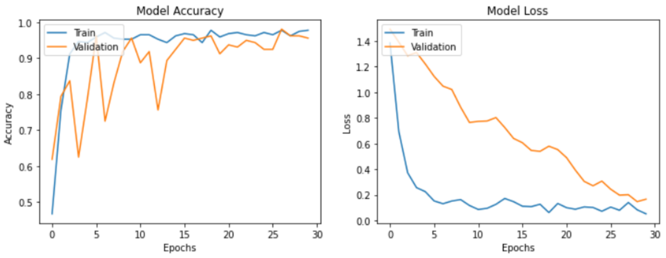

Fig 7: Accuracy (left) and loss (right) curves for CNN models with training epochs set to 30

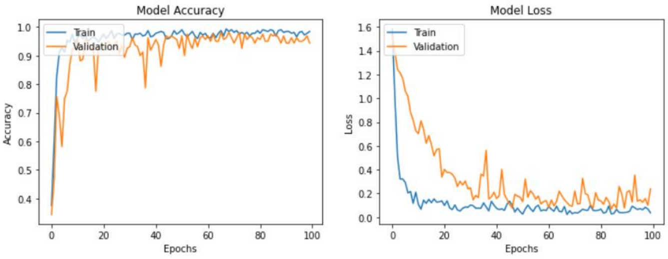

Fig 8: Accuracy (left) and loss (right) curves for CNN models with training epochs set to 100

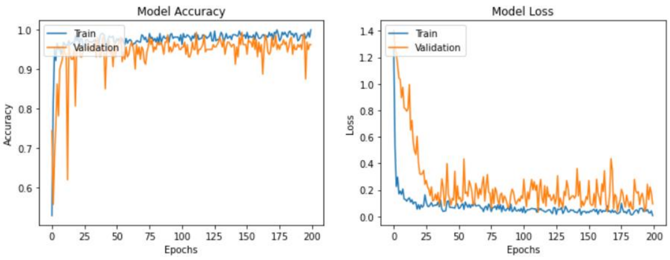

Fig 9: Accuracy (left) and loss (right) curves for CNN models with training epochs set to 200

Table 5: Performance comparison on Number of Epochs

Implemented Model	#Epochs	Augment	Accuracy	
			Fruits 360	Fruits 123
CNN Run 1	30	N	78.44	74
CNN Run 2	30	Y	95.25	96.25
CNN Run 3	100	Y	95.64	95.64
CNN Run 4	200	Y	95.86	95.86

Training the CNNs with different epochs showed restricted space for improving test accuracy. This suggested that overfitting was possible to escalate, and one may not further increase the test accuracy by simply increasing the training epochs. While data augmentation is an effective method for improving the CNN performance, it does not overshadow the importance of manually collecting more training images.

5. CONCLUSION

In this paper, we have depicted the development of a fruit detection and calorie measurement system using CNN and image segmentation techniques. We utilized a customized Fruit image dataset and applied CNN for the identification of 5 fruit classes. A five-layer CNN model was built to accomplish the best test accuracy to over 90%. CNN achieved much improved performance and efficiency than did old-style approaches mentioned in the literature review. After fruit recognition, image segmentation and calorie detection module fetches the calories and other nutrition values of detected fruit and displays it to the user. The proposed system is developed to help dieticians and patients to think about their daily intake of calories.

ACKNOWLEDGMENT

It is our privilege to express our sincerest regards to our supervisor Satishkumar Varma for the valuable inputs, able guidance, encouragement, whole-hearted cooperation and constructive criticism throughout the duration of this work. We deeply express our gratitude to our Head of the Department Sharvari Govilkar and our Principal Sandeep M. Joshi for encouraging and allowing us to present this work.

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