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FOOD CALORIE ESTIMATION USING DEEP LEARNING AND COMPUTER VISION

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Abstract: Nowadays, people are more concerned about their health due to COVID-19. A number of diseases is increasing day by day such as heart diseases, high blood pressure, diabetes,etc. These diseases are increasing due to over consumption of oily food, high sugary contents, junk food and many more which leads toobesity. Even COVID-19 has proved the importance of intake of sufficient nutrients to build a strong immune system. So, in order to keep a track of intake of necessary nutrients and to avoid over consumption of fatty and high cholesterol foods, we are proposing this system. In this paper, we proposed an image based calorie estimation system which can run on desktop system without any use of external servers. The proposed system consists of various steps such as food classification, detection, segmentation and calorie Estimation.

***IndexTerms**: image processing, food image recognition, food calorie estimation, Yolo v4 Darknet, computer vision, deep learning.*

I. INTRODUCTION

Today's young generation is more careless about their diet. They don't look after what are they eating. And as the world is getting faster, people don't consider what they are eating,
they are just busy in their work and consume whatever looks attractive even if it is highly fatty. Every time the attractive foods are not healthy. For this, we need to keep control of ourselves and keep a watch on what we are eating and how it is going to affect our bodies. Especially the people who are suffering from diabetes and obesity should take care of their calories intake. So, to keep a track of the number of calories we consume, we have tried to propose a system that will provide the calorie content present in the food by clicking its picture. In this paper, we proposed a system that can run on any browser. It can also work on localhost without internet.
To estimate the calories, present in the food, the user, first of all, needs to register a standard reference object whose size is known. Then the user needs to click a picture of the food as well as the reference object which is Image Acquisition. In this system, we are using the thumb as a reference object. After image Acquisition, the next step is image detection the system will detect the objects by creating bounding boxes around the food and the reference object. Then all objects in the image will get detected. After this, each object image is separately cropped and saved in the system for segmentation. After segmentation. We get Contour Areas, this Contour Areas will help us to find the volume of fruit. Dataset will provide the standard value of densities. By using standard formulas of volume estimation and calorie estimation we get the final output, that is calories in the particular food items.

II. LITERATURE SURVEY OR RELATED WORK-

Nevertheless, various approaches have been developed to automatically estimate the calories of food. This article will discuss them in detail.
1.We also have published the survey paper regarding this study [1] "SURVEY ON FOOD CALORIE ESTIMATION USING DEEP LEARNING AND COMPUTER VISION"

2.Koichi Okamoto, Keiji Yanai [2] "Automatic calorie estimation system for food images on smartphones" The Faculty of Informatics, Nihon Telecommunications University proposes a food calorie estimation system displayed on smartphones for consumers using this method. This includes the following steps:

2.1Take the Meal photo with the reference object here reference object which they have used is the food plate.

2.2Gathered the Required data of objects from Image using Colour Pixel-based K means clustering and grab cut.

2.3CNN algorithm is used to Identify the category of food objects.

2.4Calculate the actual food size and food calories using a pre-trained relationship between size (volume and shape) and standard calories and display them on consumer's smartphone

The system has good enough Accuracy and speed but it processes only 1 meal item at a time, the multiple food item recognition wasn't possible here.

3.Meghana M. Reddy, [3] "Calories Estimating from Food Image openCV", Github Repository, May 2016 This system used an SVM (Support Vector Machine) algorithm to classify photos. If the data is not too large, there is no problem. However, the SVM algorithm won't give good results on a large amount of data and the system proposed by Meghana, must Require the 3 objects which are reference object, food and Food plate in ascending order of size.And the author also used the thresholding methods from the OpenCV library which provides supports the segmentation of food objects.

4. Region-based convolutional neural The Network (RCNN) also features two more advanced variants of the, the Fast RCNN and the Faster RCNN, which are now widely used in object localization or detection and since it's a region-based technique is also considered to be a good choice for detection and segmentation purposes. The faster RCNN method is significantly faster than many other methods which are out there, but it also costs because it requires more GPU power to train the model on a machine. Girshicketal. [4] has developed the RCNN approach. Common detection problems are divided into two sub-problems by RCNN. Using low-level signals such as colors and textures to provide category-agnostic suggestions for object placement (RPN-Region Proposal Network) and using CNN classifiers to identify object categories... Those places to identify. This two-step approach combines the accuracy of bounding box segmentation with low-level signals with the most powerful classification capabilities of state-of-the-art CNNs. We used a similar pipeline in our detection approach but looked for improvements in both phases, such as: B. Multi-boxing.

5.Benny Cheung in blog [9] titled "YOLO for Real-Time Food Detection" has proposed a system in which he has detected the food objects. Here he has used UEC FOOD 100 dataset which contains 100 - classes of food photos. Each food object in this dataset has a bounding box around it indicating the location of the food item in the image. Most of the food classes in the dataset are from Japanese culture. In this paper , he have used Darknet's YOLO algorithm for object detection

6.According to Addie's paper [14] Real-Time Pear Fruit Detection and Counting Using YOLOv4 Models and Deep SORT, chevalier cheval The authors, Ira Borja Parico and Tofael Ahamed, have created a system that identifies pear fruits and counts the total quantity of them. They employed the YOLO technique for both Object Detection and Fruit Counting.

7.YOLO-based models for fruit detection have been used in several studies. On an NVIDIA GeForce GTX 1070 Ti GPU, Koirala et al. [17] completed real-time mango fruit recognition with their MangoYOLO model, which achieved an F1 score of 0.968, an AP of 98.3%, and an inference speed of 14 FPS. Only one study used YOLO in conjunction with a multiple object tracking algorithm to count fruits

8. Only one study used YOLO in conjunction with a multiple object tracking algorithm to count fruits. Itakura etal. [18] used YOLOv2 and the Kalman filter to count pear fruits in a video, achieving an AP of 97 percent in detection and an F1 score of 0.972 in counting. However, their counting system did not have a high frame rate. Because a depth camera is uncommon and mentioned. Because consumer smartphones lack depth cameras, implementing the method on mobile devices proved difficult

9.For Over the time YOLO algorithm Has suppressed the many object detection model which was proposed over the time and also it is a state of art and have class of its own for object detection purposes YOLO (You Only Look Once) algorithm have many versions like PP-YOLO , YOLO-V4, YOLO-V5 which are one of the most popular object detection models who is out there right now and also we have YOLO-V4 Darknet Framework and YOLO-V5 PyTorch Framework which are really popular now a days, and we can say that YOLO-Vx is currently in the development phase. So we are going to use some similar methods which we have seen above in our system.

III .PROPOSED SYSTEM

In this paper, we are proposing the Food Calorie Estimation System Using Deep Learning and Computer Vision Techniques, our system can run on a consumer's PC locally, on the web as well as providing the cloud hosting support for it, so it can run on Cloud and provide the support on users end so that the application we be lightweight and fast.

At the user's end, we expect that the user should have some graphical support inside their system with a sufficient amount of RAM and ROM at-least we expect 4GB of RAM and general integrated GPU support.

Our proposed system consists of the following phases:

1. Acquisition of images as input to the system.
2. Object Detection and identification and cropping of those desired and detected objects.
3. Images Segmentation of Objects
4. Find the approximate Volume, Density, and Calories using a predefined reference object if the reference object is present inside the image else shows only detection.
5. Display the result estimated calories with the detected object name.

* **Guidelines For Using this system:**

Since we are going to use the properties which images have

- We assume that the image should be taken from an appropriate distance where the reference object and food object are clearly visible inside of images and light intensity should be balanced as well not too dark and not too bright.
- For better results user should consider the background of the food object, if the background is uniform and have the same place color the system performance would be on top. For background, the user can use the white plane plate and out the food object inside of that food plate.
- For this current system we have only included a few food objects and reference objects as the thumb and the detection system is trained on the fresh or standard food object appearance. And currently, we have trained the detection algorithm to specifically detect fruits.

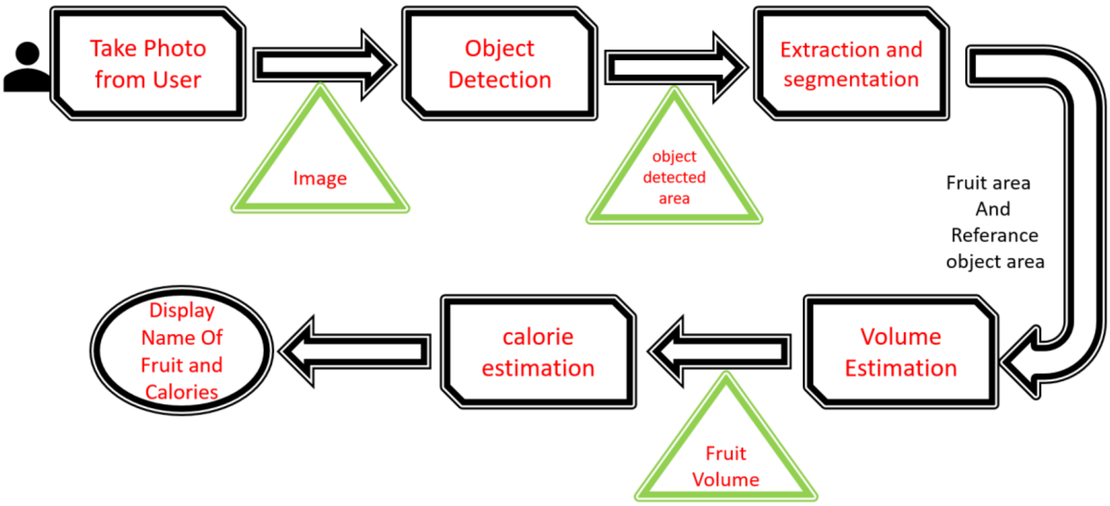


Fig 1: Flow Diagram of system

IV.DETAIL OF THE METHODS

1.Image Acquisitions:

- As the users are mostly going to use this app in real-time scenarios, so For training purposes, we need a Dataset so we created our own dataset which contains the almost 800 images of 7 different fruits categories, which have created this dataset with the help of roboflow platform where we added necessary annotations to our dataset which are the application for YOLO object detection format.
- we also augmented the data in the following dimensions.

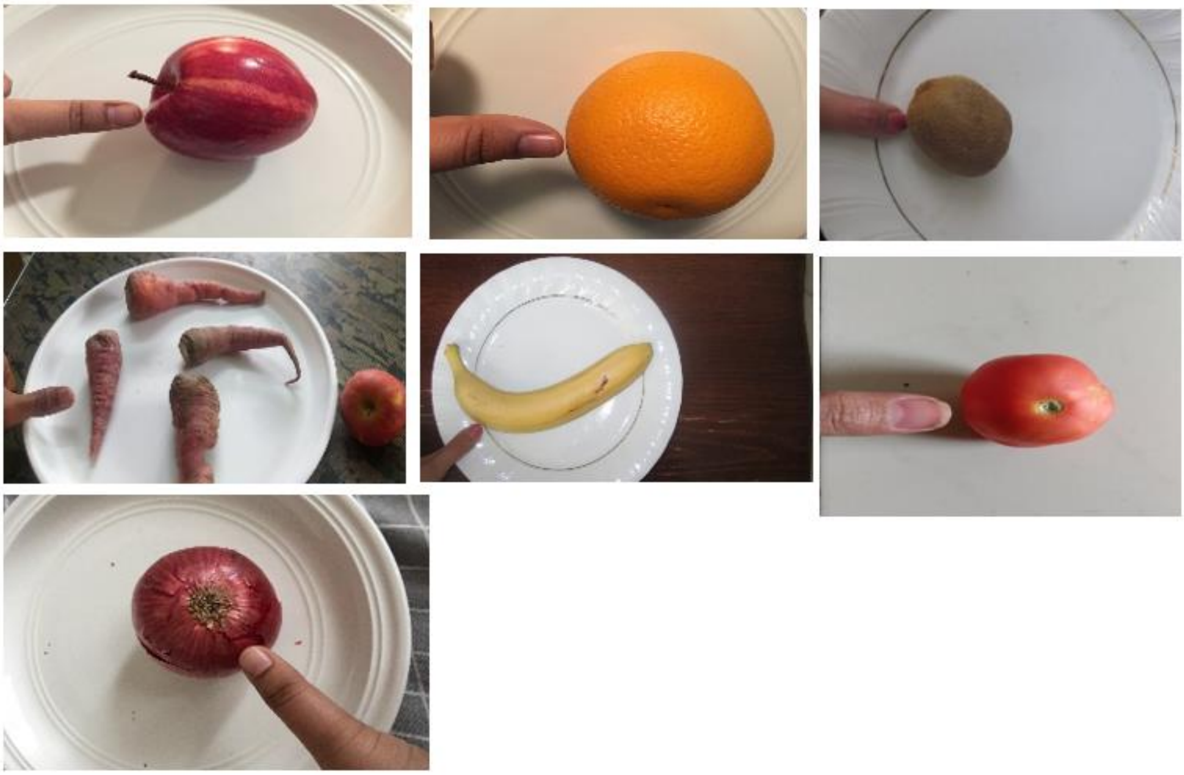
Flip: Horizontal, Vertical

90° Rotate: Clockwise, Counter-Clockwise, Upside Down

Brightness: Between -20% and +20% and we have resized the data in 896x896.

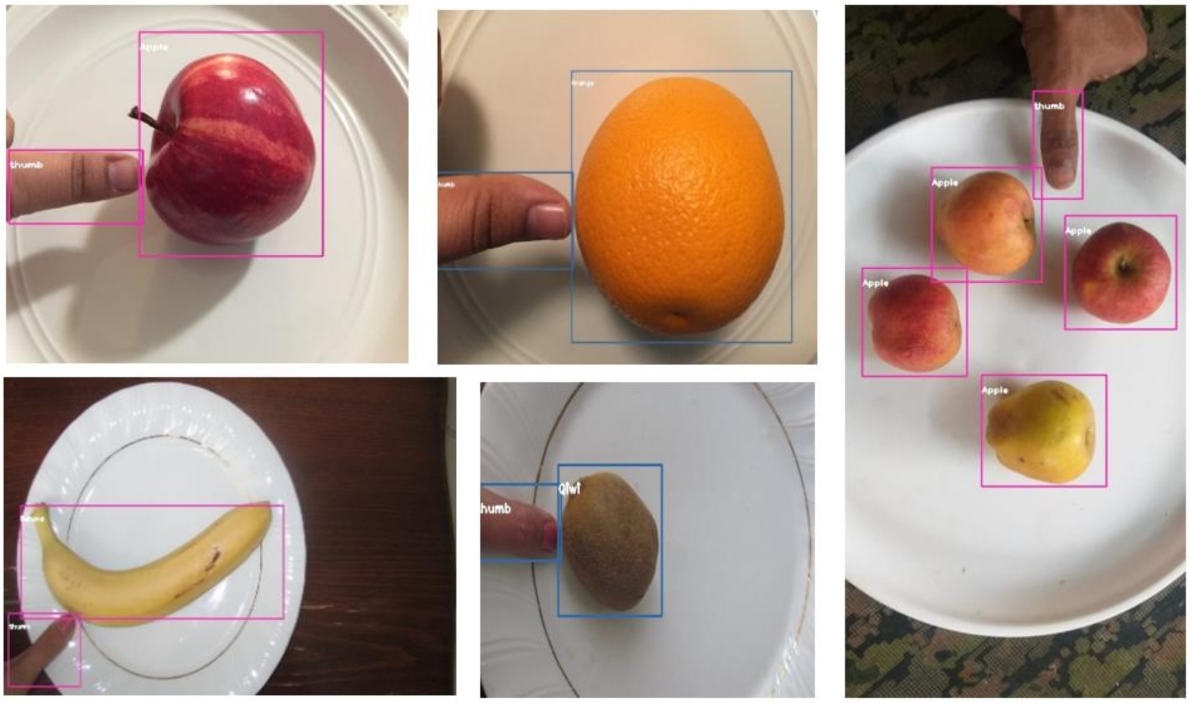
We assume that users will take photos from their smartphone or supply animage having good light intensity present in it and the background should beuniform.

For the Input we are expecting Image acquisition in following format or similar format:



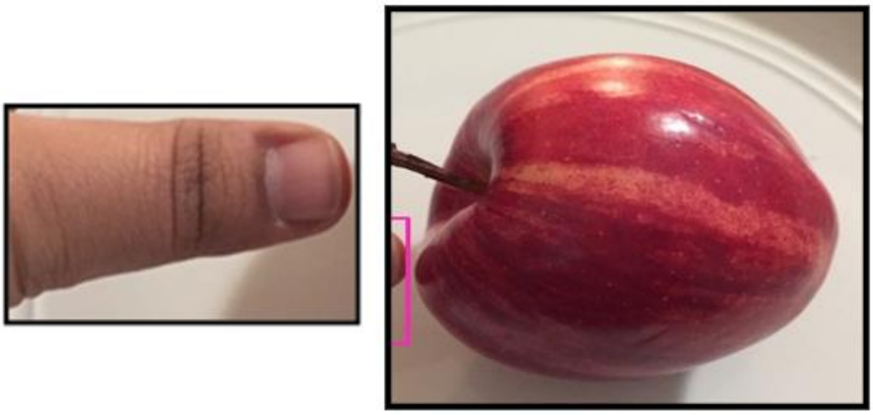
2.Object Detection:

In this step, the user will pass the image, and from that image, our system will find out the given fruit. From all the previously proposed models (e.g. [2] Meghna reddy's paper), we improve our model to give the result on multiple objects data. As we can see in the image acquisition step, we have also taken the multiple fruits data. As we are doing the supervised learning method, we have already annotated the data so our model gives the result accordingly.
Here are the classes that we have used in the model.
1.-thumb, 2.-Tomato, 3.-Qiwi, 4.-Onion, 5.-Carrot, 6.-Banana, 7.-Apple, 8.-Orange
We have to use the thumb as a reference object so we have added that too.
We have used the YOLO-V4 Darknet to give better object detection results. As its one of the fastest and beast object detection algorithms which are out there.
In our case it gives the following results:



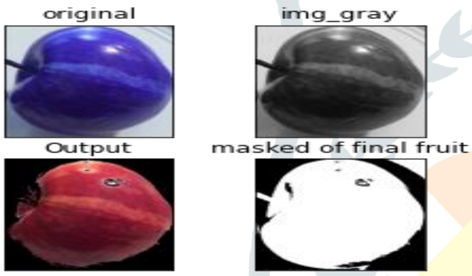
3.Cropping of images:

As we have detected the object next we have to crop the image. each object from the image will be cropped and then save as an individual image in the folder. then next step segmentation of images will be done.
As we have seen in the image above, in this step the thumb and apple get cropped separately. all other images will get cropped in same manner.



4.Segmentation:

After cropping images, next step is segmentation. In the segmentation of images, various steps are carried out. Gray scaling, thresholding of image, finding of contours, masking of image. In this step, we get the largest contour area which will help to get calories.
As we have seen the apple image above, now we will see the stepwise segmentation



5.Volume estimation:

We have 3 factors for the image segmentation

1. Foods pixel area
2. Skin pixel area
3. Actual skin area (skin multiplier)

From these factors food estimated area is given below:

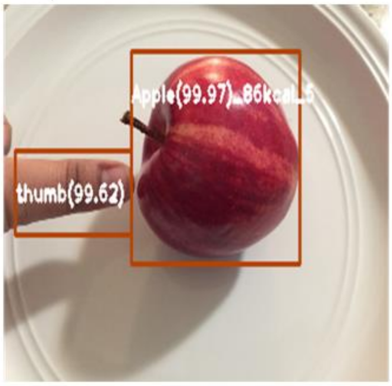
1. Estimated Food Area = Foods Pixel Area ∗ Actual Skin Area of Skin Pixel Area
   We have two types of shapes of foods 1.Sphere - like apple, orange, tomato, onion
   Cylinder – like banana, cucumber, carrot Volume estimation for Sphere:
2. Estimated Radius = $\sqrt{(\text{Estimated Food Area} / \Pi}$

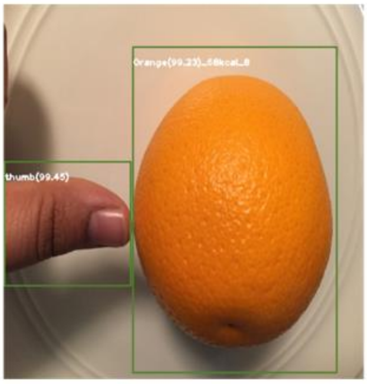
   Estimated Volume = $4 /3 * \Pi * \text{Estimated Radius}^3$

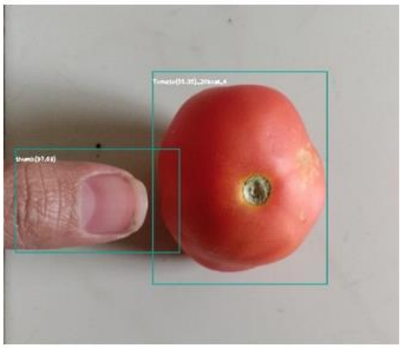
6.Calorie Estimation:

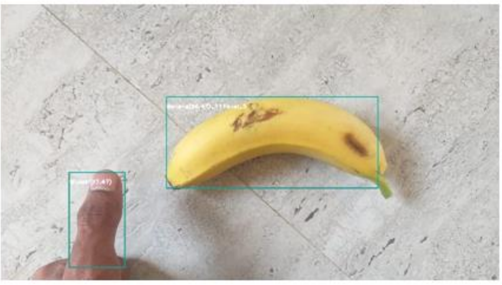
For the calorie estimation, we are going to make use of a pre-defined table having the value of labels and standard density, and also with that respect we have calorie values.
Estimated Weight = Actual Density of food ∗ Estimated Volume
Estimated Calories = Estimated Weight ∗ Calories Per 100 gm / 100

By doing all this process, we have calculated the calories, here are some results from our model









V. RESULT AND ANALYSIS

As it is mentioned in the proposed system part that to get the calories user needs to include the predefined reference object inside the input image so that calorie calculation can be done well.

In this model, we have the validation of the reference object. if the reference object is not there in the image our model will not show the calories, it will only show the detection of objects. So reference objects should be present in the image that users are passing. Also, we insist people to use white plates or white backgrounds to get better results or any common uniform surface.

- Here is the standard the Density, Calorie table which we are using In our system

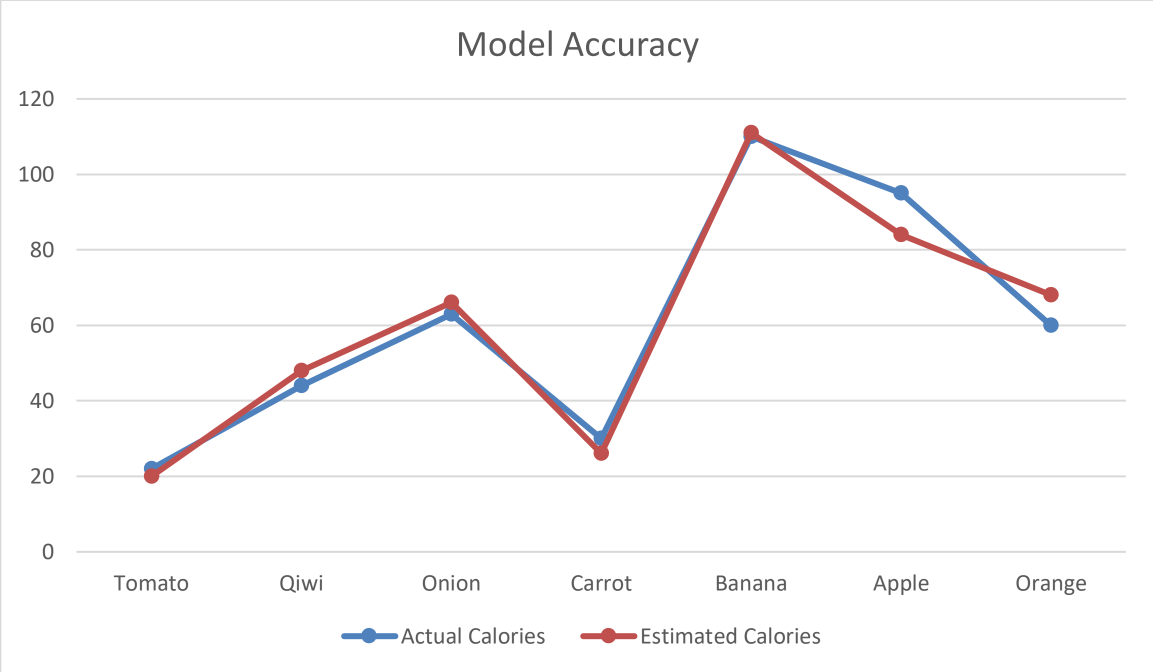
Note: thumb is a reference object.

Foods and food labels	Density g/cm3	Calories (kcal/g)	Shape
Tomato	0.47	22	sphere
Qiwi	0.575	44	oval
Onion	0.97	63	sphere
Carrot	1.04	30	cylindrical
Banana	1.14	110	cylindrical
Apple	0.96	95	sphere
Orange	0.814	60	sphere

- Here is the below Table for the Estimated calories which we got in our best-case scenarios
  The 'Accuracy' column values show the % of Accuracy calculating as
  Accuracy = (Estimated Calories by system / Actual Calories) 100.

Items	Actual calories	Estimated calories	Accuracy(%)
Tomato	22	20	90.90
Qiwi	44	48	90.90
Onion	63	66	95.20
Carrot	30	26	86.66
Banana	110	111	99.00
Apple	95	86	90.52
Orange	60	68	86.60

- Line graph that shows the plotuing of Estimated calories Vs Acutal calories of food items.



VI. Conclusion

In this paper, we proposed an image-based calorie estimation system that runs on a desktop computer without the use of any external servers. The system automatically estimates food calories by taking a photo of the food from the top or side with a pre-registered reference object.

We have used the YOLO-V4 algorithm for object detection. To recognize and localize each of the food regions we have used the YOLO-V4 darknet which has many convolution neural networks layers inside it in this system, we have used the simple segmentation methods from computer vision therefore it is difficult sometimes to treat a food image with not sufficient light intensity, the non-uniform background behind the food object

We plan to incorporate more sophisticated segmentation algorithms in the future, hopefully, state-of-art region-based with CNN methods for this process we can conclude that our Computer vision which is used for segmentation deals with the image really quick, and calories calculation is fast enough for object detection model YOLO-V4 which we have used is highly accurate and give really faster detection result.

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