Fruits Calorie Prediction Using Machine Learning

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APPROVAL

This Project titled **"A Comparative Analysis of Machine Learning Approaches for Fruits Calorie Prediction"**, Submitted by **Monisha Tasmin Moni**, ID No: **201-16-535**, to the Department of Computing & Information System, Daffodil International University has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of B.Sc. in Computing & Information System and approved as to its style and contents. The presentation has been held on 29-09-2024.

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DECLARATION

I, **Monisha Tasnim Moni** hereby declare that; the work in this dissertation titled **"A Comparative Analysis of Machine Learning Approaches for Fruits Calorie Prediction"** has been done by me under supervision of **Mr. Israfil**, Lecturer, department of Computing and Information System (CIS) of Daffodil International University. I am also declaring that this project or any part of there has never been submitted anywhere else for the award of any educational degree like, B.Sc., M.Sc., Diploma or other qualifications.

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I also extend my heartfelt respect to our honorable Md. Sarwar Hossain Mollah, Head of the department, for his valuable suggestions and inspiration throughout the study period. I am thankful to all the teachers and members of our Computing & Information System (CIS) Department.

Lastly, I am sincerely grateful to my beloved parents, my younger brother, and my friends for their moral support and valued encouragement throughout this journey.

DEDICATION

I dedicate this work to my father, Md. Mozaffor Rahman, my mother, Tajrina Begum. Without their blessings, advice, and support, along with the guidance of my repected supervisor Israfil and the encouragement from my younger brother Tangimul Hasan Tanim, this thesis would not have been completed.

ABSTRACT

The proposed method in this work provides a unique solution through image-based analysis for predicting fruit calorie content using object detection and segmentation with the YOLOv8 model. The model was trained on a custom dataset comprising diverse fruit images to detect and segment seven types of fruits. From the segmented fruits, we computed the relative area of each fruit, which served as a predictor in estimating calories using a linear regression model. The goal was to create an effective, reliable food-image-based calorie estimation system.

The YOLOv8 model performed exceptionally well in fruit detection, achieving precision and recall almost equal to 1.00 for all categories except for oranges, where the F1-score was slightly reduced to 0.99 due to a high missed ratio of approximately 2%. The model's fruit detection and classification tests demonstrated an accuracy of 1.00, reflecting its robustness in identifying fruits.

The linear regression model achieved an $R^2 = 0.987$ for calorie estimation, showing a high correlation between the fruit area and calorie content. The model captured 98.7% of the variance in calorie values, demonstrating its ability for accurate predictions based on the segmented fruit areas.

Major outcomes of this study include high accuracy and the ability to detect and segment fruits using YOLOv8. The fusion of improved object detection techniques with simple machine learning models for nutrition estimation proved to be effective. Overall, this system provides a calorie estimation tool that can assist users in mobile health applications, smart kitchen appliances, and dietary consulting services. Future work includes expanding the range of fruits in our dataset and exploring more sophisticated machine learning models to enhance calorie prediction accuracy. However, the generalizability of this study may be affected by restrictions in terms of fruit types and lighting conditions from which the dataset was prepared.

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Chapter 01

Introduction

1.1 Introduction

Estimation of calories a day is not enough in the recent days when health has got utmost importance. The majority of the traditional approaches comprises bulky mathematical equations, and consideration to labelling that it becomes nearly impossible for a person involved here, in counting his intake. The ultimate vision of this research is to change how calories are counted using computer vision and machine learning. An approach to allows the system automatically classifying fruits in it for calculating calories per fruit is proposed here to build and use. So it is one of the innovative solutions to health problem in which it offers a very simple, yet for anyone who wish what type should come on your plate and an cool way. This services are not completely only on a personal level as if we can apply this research, it might be beneficial for us.Response Entity Blog It could I guess be used as a personal health if wearables, smart kitchen or even dietitian. This helps to provide instant calorie information to the people; when this happen, anyone can become smarter about their weight. This paper, in this sense can be an aside for the computer vision and machine learning area because it is used as a leverage to start talking about something pragmatic that really impacts on our health. Hence we hope that by developing these prevalent models of fruit-calorie will be beneficial for the upcoming trend in terms food recognition and dietary analysis (related fields).

1.2 Aims of the Study

This work is mainly about proposing a system that can accurately determine the fruits calorie from images upon which you can rely. The computer vision will extract the fruits in-side images and segment it then machine learning models would predict calorie value of each fruit to detect current eaten calories from features of image retrieved.

1.3 Objectives of Study

Specific aims of this study The research questions being posed in the present research are as follows: This is in terms of a method to achieve these objectives

1. **Create a powerful object detection and segmentation model:** Train good precision of identifying fruits by using more advanced algorithms, derive the position where any fruit occurs over images.
2. **Select intrinsic visual features** : that could potentially be associated with the fruit calorie content is it shape, size or color?
3. **Design multi staged machine learning:** Create a high accurate and robust ML model that will learn to predict the calorie content of each fruit based on visual features extracted from images.
4. **Measure how well the model performs:** It is important to measure out put with suffcient criteria of evaluation in order for system developed be checked on qaulity.

1.4 Motivation for the Study

This requirement necessitated the development of easy to use, readily understandable tools for dietary intervention and was therefore a major reason underpinning this study. Approaches Used In The Past To Measure Calories Have Taken A Lot Of Time And Many Were Lousy With Errors It is also easy for both the service provider and end user to manage their calories if only an image based system was used, thus facilitates users with consumption of right quantities at high quality.

However this research is not only for applying computer vision and machine learning in real-world applications around a serious problem that affects the public health of society but also contributes some theoretical, practical value to the field.

1.5 Limitation of the Study

This work will be dedicated to the estimation of energy value, in whole with an eye on a some choice fruit. The scope includes:

- **Fruit Categories**: System will classify fruit, The fruit dataset for testing training; apples, oranges, bananas,mangoes and leechesjava-plums.
- **Type of Images:** The images in the system will be mainly confined to pictures showing only single fruit or maximum few fruits. Two or more items; and particular scenarios with hidden object of interest are out-of-scope for the present research.
- **Calorie Estimation:** The system will estimate calories in 100 grams of tropical fruits category.

Even though this study focuses on fruit calorie estimation, the procedures and methods discussed here are generalizable to other types of foods for future research.

1.6 Structure of the Dissertation

Algorithm development and evaluation are discussed throughout the rest of this dissertation as a five-chapter organizational structure, such that each chapter builds on concepts to be elaborated in subsequent chapters in order to present an instantiated framework for potential future research directions (fruit calorie estimation).

Chapter 1: Introduction

Chapter 1 provides the motivation behind this research and explains how there is a need for an automatic system built using computer vision (CV) algorithms augmented with machine learning(ML), that can accurately estimate calorie content of food items. The boxes help in considering the research objectives, aims and limitations at individual level, therefore contributing to a rationale for both this overarching study. This is followed by an exploration of what motivated us to choose this problem, referring to usual calorie counting methods drawbacks.

Chapter 2: Literature Review

In this chapter, a detailed literature survey on existing approaches and methods for food recognition and calorie estimation using computer vision (CV) /machine learning(ML) are presented. It profiles the most important advances in object detection and segmentation methods, addresses newer works relying on visual features for food classification, and reviews available models for calorie estimation. Finally, the chapter closes with an exploration of what we do not know based on previous research to be illuminated in this study.

Chapter 3: Methodology

This chapter includes a detailed discussion of the methodologies that were used in conducting this research. The document details the dataset data collection process, how it has been preprocessed and augmented for training different models with object detection or segmentation tasks in both image context as well, machine learning algorithms used for calorie estimation. It describes each phase during the development of a system, from feature extraction through model training and evaluation. We justify the technical choices in system design. We provide reasons on why a multi-stage machine learning pipeline was used

The Results and Discussion Chapter 4

Chapter 4 gives a report of the results that were achieved by running experiments with this system. Different evaluation metrics such as precision, recall and accuracy is calculated for fruit detection model and calorie estimation model performance. This is followed by an analysis of the results vis-à-vis research objectives and a critical evaluation of what exactly worked (and not). The contributions of the proposed system are also compared with previous approaches in this chapter.

Chapter 5 Conclusion and Future Work

The final chapter recaps the major learnings of this research work and also shares its insights to computer vision, in addition dietary analysis. The previous study restrictions are taken back, while some possibilities for future research could be suggested: expanding the system to other foods classes; increasing its precision by optimized algorithms and more extensive data. The chapter ends with a discussion of the implications for personal health management as well as public applications within global health.

Ever chapter supplies the reader with valuable context and a clear detailed explanation as to how each study, from its inception to conclusion and eventual next steps.

Chapter 02

Literature Review

2.1 Background Study

Just think about it, let me explain the futility of trying to determine how many calories are in that delicious apple you are planning to consume. I think it can be slightly challenging, can it not? Conventionally, this would require a look at the nutritional information table or a couple of advanced arithmetic problems. But what if there was a much easier approach?" But that's where computer vision and machine learning come in to play several key functions and steps in the process. Just imagine that you are explaining something very simple to the human brain – like, for instance, teaching a computer how to interpret images. This involves feeding the computer with numerous pictures of different fruits and the respective calorie details so as to give it techniques to estimate the potential calories from the fruits by merely viewing them. What a great concept: an individual's calorie partner that can be found right in one's palm?

2.2 Related Work

A. Singh et al. analysed the use of CNNs integrated with image processing with a view to classifying food images and identifying their rather calorie content. The purpose of this research shall be to assist people in making more appropriate food selections and consequently, controlling the caloric consumption for improved health. The study shows a high level of accuracy on food item classification on the basis of deep CNN architecture. Also, it computes accurate calorie estimate from the visual characteristics, which is important in caloric analysis. The work also focuses in the potential of technology in assisting in educated decisions on nutrition and calorie intake control [1]. Manal Chokr et. All thesis work outlines a supervised machine-learning approach to predicting calorie contents of foods from the pictures of those foods, which food type, size, and thus calorie values are to be determined. The three steps outlined above are dramatically better than simple baseline approaches that seek to predict calories directly. They allocate recognition of the food type, the estimation of the portion size, and the calculation of the calories into three phases, which give better accuracy of the calorie estimation. This pipelined approach has been illustrated in this research to accurately estimate calorie levels from food images and hence can be considered as a more reliable method in the analysis and management of diet [2]. First Teddy Surya Gunawan work include his study on the employ of Generalized Regression Neural Network (GRNN) to predict calorie intake from the image of 568 different foods. While the study demonstrates the application of GRNN in calorie prediction, it highlights a significant challenge: large variance of calories in foods resulting in large prediction errors. These errors perhaps can be minimized, in line with the research, by providing more training data or using a deep neural network which may enhance the accuracy of calorie predictions from food images [3]. Shaikh Mohd. Wasif's work on practical methodology of calorie estimation in food uses machine learning and image processing to create a software tool that would predict calories with high degree of precision. Object detection in the system uses Faster R-CNN, GrabCut is used for image segmentation while estimating the calories using the volume of known probe object. The outcomes of these three modules, to wit object detection, image segmentation and calorie calculation are reviewed in the research individually as has been earlier pointed out. The experiments were performed on an Intel Xeon with specific technical characteristics; the feasibility of calculating food calories is confirmed by this combined method [4]. The research paper for S. Anusuya provides an enhanced method for food calorie prediction by leveraging a hybrid deep-learning aproach or CNN and the Extended Kalman Filter. It enhances the accuracy of calorie analysis from the images of foods by a very huge percentage. The results obtained and shown in MATLAB are expected in proving the uniqueness of the hybrid layers in improving the quality of the image during food processing. Besides, the incorporation of the CNN with the Kalman filter helps to enhance the accuracy of the prediction while developing a new approach that raises the efficiency of the study [5]. Coming to the novel contributions of the study initiated by Ritu Agarwal, the work presents a novel hybrid deep learning system, intended for food recognition and calorie estimation tasks with the accuracy rate of 97%. 12%. It includes key parts for segmentation, classification, and volume to eliminate the margin of error and allow accurate calorie prediction. Besides the volume of food consumption, the algorithm also gives advice on food consumption, hence making it a good instrument for managing food habits [6]. The research of Parth Poply employs instance segmentation with Mask R-CNN to assess the food calories. Due to identification of food objects, computation of their surface area and use of calories per sq inch estimation the study obtains high percentage accuracy. In particular, it obtains a mean Average Precision (mAP) of 0. 93. 7% for a food item detection and 95 for a style detection on the garments. These methods have been shown to be accurate to within 5% for calorie estimation, the utility of this approaching for dietary analysis [7]. It is on food calorie estimation using image segmentation that Shreya Anil Kubade based his research while using deep learning. It is possible to note that the study provides high results: segmentation accuracy more than 90% and an average of error in a calorie estimation no more than 10%. The effectiveness of this measure in the dietary analysis and nutrition can be concluded by the increased precision of the food identification and the estimation of the calorie content [8]. Kiemeney L. A. L. M's research article is solely focused on real-time food identification and calorie estimation and its governing deep learning model. To this end, the study uses YOLOv8 and TensorFlow in developing a system that would be able to provide information on 100 different type of foods and the relative calorie content in each of them. This approach focuses on the implementation of state of art deep learning methodologies for intelligent diet planning, for correctly estimating calorie intake, in real world settings [9]. P.A Introduces in his/her research paper: A Deep Learning Based System for Calorie Estimation from Food and Beverage Images for Calorie Intake Monitoring and Obesity Related Diseases Prevention The system achieved 78. During the testing, Taster achieved only 7% accuracy in the identification of food and 93. Observing 29% accuracy during the training process which reveals that with the help of this program it is possible to give correct indications about the sort of the food products and calculate the number of calories it contains. This system is rather helpful to maintain the dietary habits by means of accurate calculation of energy intake [10]. The research paper presents and analysis of a deep learning system to estimate calorie from the pictures of foods and drinks in order to monitor calorie consumption and minimize obesity diseases. The system achieved an accuracy of 78. It was also observed that all the participants performed dismally in food identification with a mean of 7% during the test and 93. 29% during training. It can also estimate the number of calories in food images making it plausible for persons to ascertain the appropriate eating regimen [11]. The intent of the research paper is to develop an intelligent mobile application that can analyze food calorie using artificial intelligent and deep learning. The app achieved 83. Compared with applying the knowledge on cellular-base approapx approaches, using the knowledge for scoring 11 types of categories of food occupational ill-health based on image inputs can only got an accuracy of 44%. Further to this, over-fitting was tackled well through the use of a Dropout layer that improved the model. The primary reason for this is so is that the optimized MobileNet model obtained a recognition accuracy of 76. 69 % of them gave a positive response agreeing that a mobile application that provides a method for analysing food calories is useful [12]. The aim of the research paper is to discuss an image recognition approach that shows the usage of Support Vector Machine technique to approximate the caloric content of food for Thai cuisine. Since this method helps to output correct calorie breakdown, it proves helpful in encouraging the uptake of better meals. The algorithm overall has an accuracy of about 70% which indicates that it has a rather high level of error since the ground reality of food images with sufficient texture is a little higher – but of course the outcome of the algorithm can vary slightly depending on the variety of the food images used in the test results. In the food image recognition the SVM-based method was applied in order to recognize the food images and to create feature vectors that can be used for successful approximation of the consumed calories [13].

2. 3 Limitations from the Previous Study

While the existing literature provides valuable insights into fruit-related image analysis, there are several limitations that need to be addressed. While the existing literature provides valuable insights into fruit related image analysis, there are several limitations that need to be addressed:

- Limited Datasets: A number of sharable algorithms' researches have been carried out with the help of availability of limited big, high quality data sets, which pose a problem to the construction of proper models.
- Focus on Classification: While many papers have been published, few of them were aimed at directly solving the problem of calorie content prediction; instead most of the work was done in the context of fruit classification or in terms of ripeness estimation.
- Lack of Standardization: Most of the studies still have a poor reporting standard in data gathering and analyzing methods, and criterion on which the results are assessed.

To overcome the above limitations, this research endeavours to make a significant contribution in the following ways. this study proposes to use a large scale dataset for the experiments, more specifically the task of calorie content prediction, and uses a very strict evaluation protocol.

Chapter 3

Methodology

3.1 Introduction

In this chapter we present our methodology to extract the Caloric Fruit Image Dataset in estimating fruit calorie content from images. We started by collecting a fruit dataset containing images taken from the internet and of a Kaggle Dataset. We use this data to detect and segment fruits in these images using YOLO (You Only Look Once) model which is an efficient method for Object Detection.

Linear regression model of fruit region after segmentation to predict calorie content using size and type. This chapter focuses on explaining each phase of algorithm including data collection, preprocessing,model training and tools which laid the foundational stones to analyse results later in other chapters.

3.2 Data Collection

The success of the machine learning model generally played a central role in which dataset you used to train and test it. We collected six types of fruit images: apples, oranges, mangoes, bananas, lychee and java plum in our datasetfra (as shown by the examples above.)

3.2.1 Kaggle Dataset

The methodology to get this wheel spinning was a database we already had access to, from Kaggle that acted as our blueprint! This dataset included:

Fruit Classes: The dataset consisted of images from six different types of fruits namely apple, orange,mango, banana and two regional fruit flavours litchi and jamun.

No of Images: Almost 50 images per class for the fruit, so in total to around 300 or near.

Consistent Images: The dataset includes images captured from same distance to keep scale and perspective the same across all pictures — essential for accurate calorie prediction.

Calorie Information: Each image came with its respective calorie content (per 100g), affording us the ability to map out our visual data against nutrition.

Composite Fruit Images: There were also a few images that contained multiple fruits which may confuse the classification model as well. In this work, these images provide an extra challenge as precise segmentation is needed to find and segment the fruits that are so close together.

Figure 3.1: Image of Fruit dataset

Table 3.1: Calorie Representation in CSV File

Image	**Category**	**Calory**
apple1.jpg	apple	50.44
Org43.jpg	orange	74.26
banana16.jpg	banana	43.61
lychee25.jpg	lychee	13.86
mango10.jpg	mango	58.8

3.2.2 Supplementary Data Collection

Recognizing the need for a more extensive and varied dataset to effectively train our object detection model, we manually collected approximately 1,000 additional images from various online sources. This supplementary dataset was designed to enhance the diversity and robustness of the model by including:

- **Varied Backgrounds:** Unlike the Kaggle dataset, the images collected from the internet featured a variety of backgrounds, lighting conditions, and fruit arrangements, simulating real-world scenarios more effectively.
- **Multiple Fruits:** Many images included multiple types of fruits, sometimes overlapping or partially obscured, adding complexity to the task of object detection and segmentation.

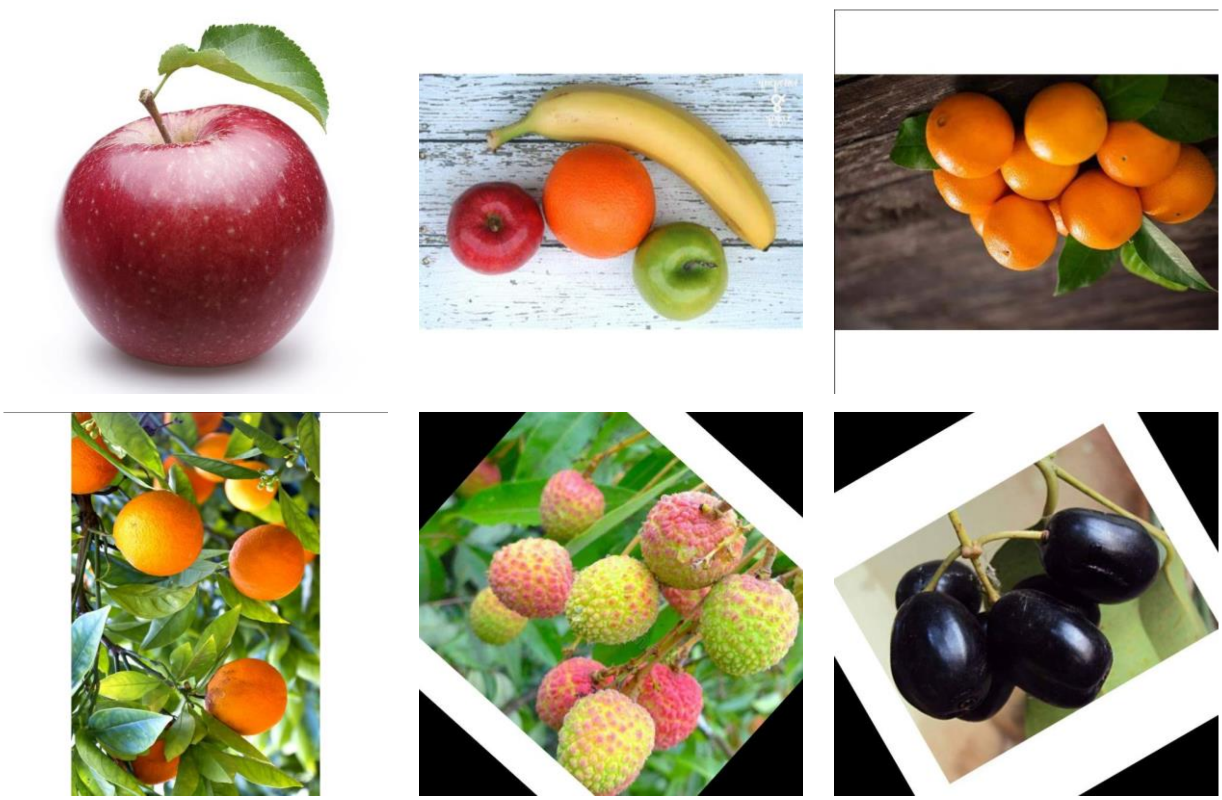

Figure 3.2: Data collection for Fruit Detection

3.2.3 Data Labeling

In order to train the YOLO model with this dataset, all images were labeled and preprocessed neatly by using Roboflow's script-free image annotation tool for object detection tasks. The process of labelled was:

Mask Annotation: For every fruit present in the images, annotations were provided as pixel-wise masks instead of bounding boxes. The masks provided us with the precise shape and limits to of fruits that could be used for segmentation. These masks were created in order to differentiate each fruit type within the image so that when our model was learning, it could learn how to correctly identify which fruits are one and even if they overlap or some of them remain hidden.

Class Labels: Every mask (segmented region) was assigned a class label of the corresponding fruit type such as apple, orange and others to guarantee that not only will segments with fruits be detected by model but also classified properly.

Data Augmentation: Additionally to augment the data and make the segmentation model more robust we implemented a bunch of different Data Augmentation techniques. This included rotations, flips and zooms as well color adjustments which artificially increased the variety of training data. We augmented the dataset to 3,000 images using augmentation which creates a variety of situations that can be used by our model.

YOLO-Compatible Format: The final labeled data was pre-processed in such a way that it can be easily consumed by the YOLO model desipite being using masks for segmentation. To be compatible with YOLO framework one has to follow these steps, you have to format the masks and their respective labels so that it can integrate easily in our segmentation pipeline.

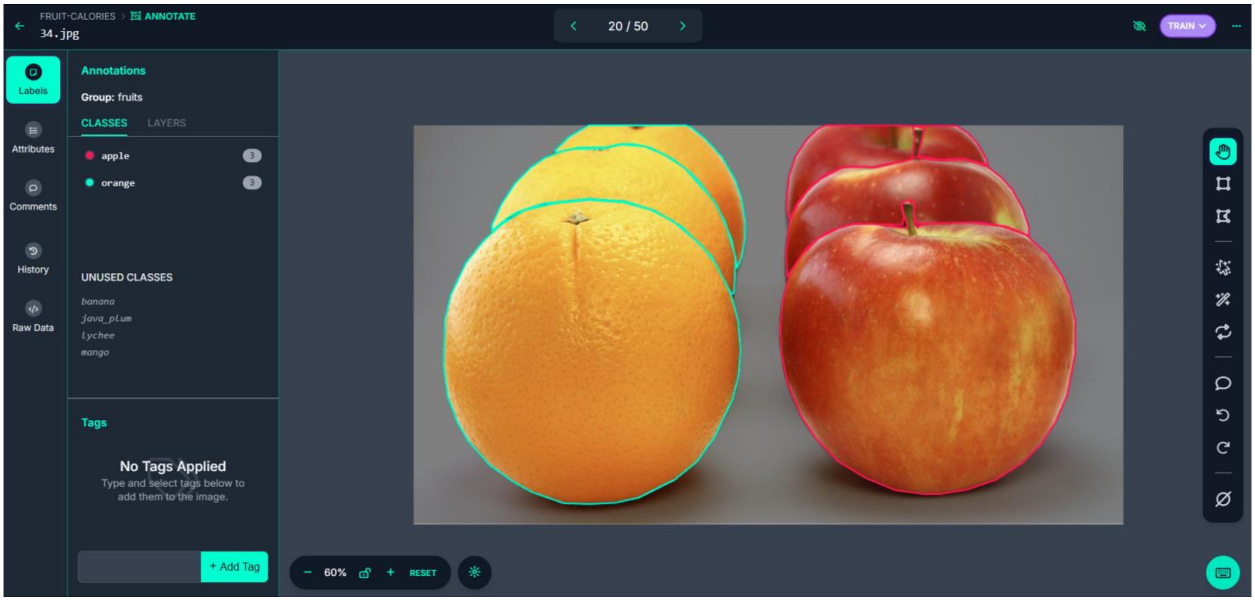

Figure 3.3: Mask Labeling of fruits image

3.3 Object Detection and Segmentation using YOLO

Here, we detail the object detection and segmentation used in this study with an emphasis on YOLOv8. YOLOv8 (You Only Look Once version 8) is the most recent addition to an esteemed family of object detection models, celebrated for both its high speed performance and robust generalization across Object Detection & Segmentation tasks. In the previous section, we discussed its architecture and key components; this part details how YOLOv8 was implemented for fruit segmentation and calorie prediction.

3.3.1 YOLOv8 Architecture

While YOLOv8 is based on the original principles of its predecessors, it contains a number of changes which further improve accuracy and provide huge speed increases over traditional models. Key Features and Architectural Elements of YOLOv8

YOLOv8 Backbone Network : An advanced backbone network is utilized for YOLOv8 usually come from CSPNet (Cross Stage Partial Network)so that possible to effectively realize the feature extraction. Figure 3: The input image is passed through multiple convolutional layers in the backbone, capturing hierarchical features from low-level edges to high level semantic information. The backbone of YOLOv8 is designed to strike the right balance between computational efficiency and feature extraction capabilities, which helps in extracting high-level semantic features from input images while maintaining its speed.

It also includes the neck part of YOLOv8 that encapsulates a few feature pyramid networks (FPN) and pan aggregation network which learn to adaptively enhance features by combining low-resolution, high-semantic information with high-resolution, low -semantic information. This fusion enables YOLOv8 to give more precise predictions at multiple scales, making it especially useful for multi-scale object detection.

Head: This is the last head of YOLOv8 that predicts final predictions such as bounding boxes, class labels and for segmentation tasks they would use a pixel-wise mask too. Anchor boxes together with gridding cells are utilized for detecting the position, scale and category of objects using this head. An extra output layer was also added for segmentation in order to produce the segmentations masks of all found objects.

Even Anchros-Free mechanism: One of the important progress in YOLOv8 is it adopted anchor-free even anchors free style to simplify its model by removing predesigned anchor boxes. Instead, YOLOv8 directly predicts centers and sizes of objects which reduces computational complexity and make the model degreeless sensitive to object scales or/and aspect ratios.

3.3.2 Implementation Details

We chose YOLOv8 for this study since it offers a competitive performance in object detection and segmentation while being efficient (which is key point to be able to process real-time applications). In the previous section, we explained our curated and augmented dataset with over 3k labeled images that was used to train this model.

Training Phase: We used the YOLOv8 model for training, our datasets with class-labeled focus on accurate segmentation over 6 different fruit classes. Before explaining more about the Inceptional network, let me show you how it was trained using stochastic gradient descent with back-propagation to optimize weights and gradients for model training over an adaptive learning rate.

Data Augmentation : Data augmentation was one of the key in enhancing model robustness. Random rotations, flips and color adjustments were used as additional techniques during training to help the model generalize well under different real-world conditions.

3.3.3 Advantages of YOLOv8

Based on the above, YOLOv8 provided several key advantages which made it a good choice for this research:

Real time performance: YOLOv8 is real-time application design that speeds up with high process images without affecting accuracy. This has made it useful for fruit segmentation, in situations where quick and accurate segmentations are needed.

Accuracy is improved: The architectural improvements from YOLOv8, along with the anchor-free mechanism and enhanced feature fusion result in higher accuracy for object detection as well segmentation tasks.

Dual-purpose: The fact that YOLOv8 supports both detection and segmentation within its framework means that the system doesn;t have to make use of a wide array of models, streamlining it altogether.

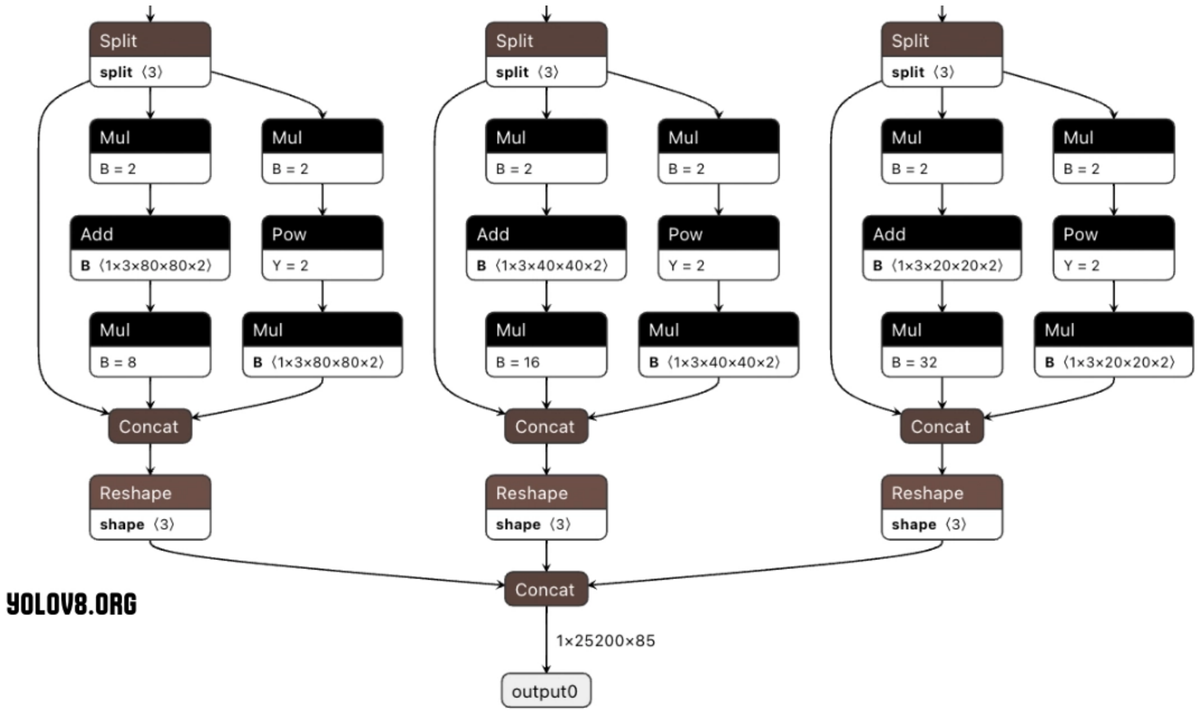

Figure 3.4: YOLOv8 architecture

3.4 Feature Engineering and Area Calculation

In order to enhance the predictive power of our calorie detection model, we introduced an additional feature — the area of the detected fruit, which was calculated using the segmentation output from the YOLOv8 model. By incorporating the area of each fruit object, we provided the model with more context for estimating calories, as the size of the fruit in the image directly relates to its calorie content.

3.4.1 Area Calculation Using YOLOv8 Segmentation

Once the YOLOv8 segmentation model was trained and capable of accurately detecting and segmenting fruits within images, we used it to calculate the **area** of the segmented fruits. The formula used to calculate the area of an irregular shape, such as a fruit in an image, is based on the coordinates of the polygon that defines the segmented object:

$$A = 1/2(x1y2 - y1x2) + (x2y3 - y2x3) + \cdots + (xny1 - ynx1)$$

Where:

- $(x1, y1), (x2, y2), \ldots, (xn, yn)$ represent the coordinates of the polygon that outlines the fruit in the image.
- The formula sums the determinants of consecutive points and divides the result by 2 to compute the area.

By applying this formula to the segmentation masks generated by YOLOv8, we were able to predict the area of each fruit object in every image. This area is critical for estimating calorie content because larger fruits are likely to contain more calories.

3.4.2 Feature Augmentation: Adding the Area to the Dataset

Once the areas were calculated, we augmented the original Kaggle fruit calorie dataset by adding an area column. This new feature was appended to the existing dataset, which initially consisted of the image file name, fruit category, and calorie content.

Table 3.2: After Feature Augmentation

Image	category	area	calorie
apple1.jpg	apple	23.295898	50.44
apple2.jpg	apple	23.525391	54.08
apple3.jpg	apple	24.337562	52.52
apple4.jpg	apple	26.044924	60.32

By introducing the area as an additional feature, the dataset now provides more relevant information to the model, improving its ability to predict the calorie content of the fruit based on both its category and size.

3.5 Training The Linear Regression Model

The next step was an exercise in training a linear regression model with the area of fruit as the feature to predict calorie content. But we realised that as it is different types of fruit have different massink (as in calorie density, ie the number of calories per unit area or volume). As such, it was necessary to adjust for this variability by creating subsets of the dataset through which we could train with different fruits only.

3.5 Splitting The Dataset By Fruit Category 3.

As an example, both the apple type 'boiled-apple'is a common fruit which is part of many diets and has 0kcal/100g while wine contains no (52)…wikimedia.org Each subset corresponds to one category of fruits; we get six sets off this way. It allowed us to fit linear regression models separately for the fruit classes, so that each of their calorie characteristics were taken into account.

In the dataset, there are six subsets:

Apple dataset (50 samples)

Orange dataset (50 samples)

Mango dataset (50 samples)

Banana dataset (50 samples)

Lychee dataset (50 samples)

100K R Chain — Java Plum dataset (50 samples)

Dataset 1 had features area and calory, using them to train linear regression model for each category of fruit.

3.5.2 Linear Regression Model

As an example we used a linear regression model to predict the calorie content of these fruit based on their area. The linear regression model is defined as follows:

$$Calory = \beta 0 + \beta 1 \cdot Area$$

Where:

Calory is the estimated number of calories.

Area: Area=cellular fruit area measured by YOLOv8 segmentation modelutils.

Here, β0,β1 are Intercept and slope of linear regression model.

For every category of fruit, a linear regression model was trained on the respective set by learning how big the fruit is and what it has in terms of calories.

3.5 Model Training and Evaluation

Training: Each of the six fruit-specific linear regression model was trained on 80% given dataset and evaluated against remaining 20% data.

Performance Metrics: The model performance for every prediction was evaluated on the standard regression metrics like;

- **Mean Squared Error (MSE):** Calculates the mean of the squared errors between actual and predicted calorie values.
- **R^2 (R-Squared):** Specifies the percentage of variance in calorie content that can be accounted for by fruit area.

That was, we trained models on each fruit type one by and that is why the model reaching a very high accuracy comparing to our above-used single-model for all fruits. Taking into account these calorie charactirstics (between each fruit) achieved a more accurate prediction of the procedural use.

3.6 Conclusion

We presented a complete pipeline for fruit calorie detection in this chapter, starting from data collection and labeling followed by segmentation using YOLOv8 model building up to feature engineering with linear regression. Incorporating the segmented fruit area as a new feature allowed us to improve our predictions by incorporating this information. Doing this type of data separation per fruit, before training the linear regression model gave us a way to take into consideration that notion and therefore have our predictions far more realistic, as it surprises in protected. In this paper we present the introduction of a systematic framework for calorie estimation by visual data, which will provide an effective mapping function based on well established theory.

Chapter 4

Results and Discussion

4.1 YOLO Model Performance Evaluation

The YOLOv8 model demonstrated high performance in detecting and segmenting fruits from the dataset, accurately identifying 349 out of 350 fruits. The model's effectiveness is further quantified using precision, recall, F1-score, and accuracy metrics, as detailed in the classification report.

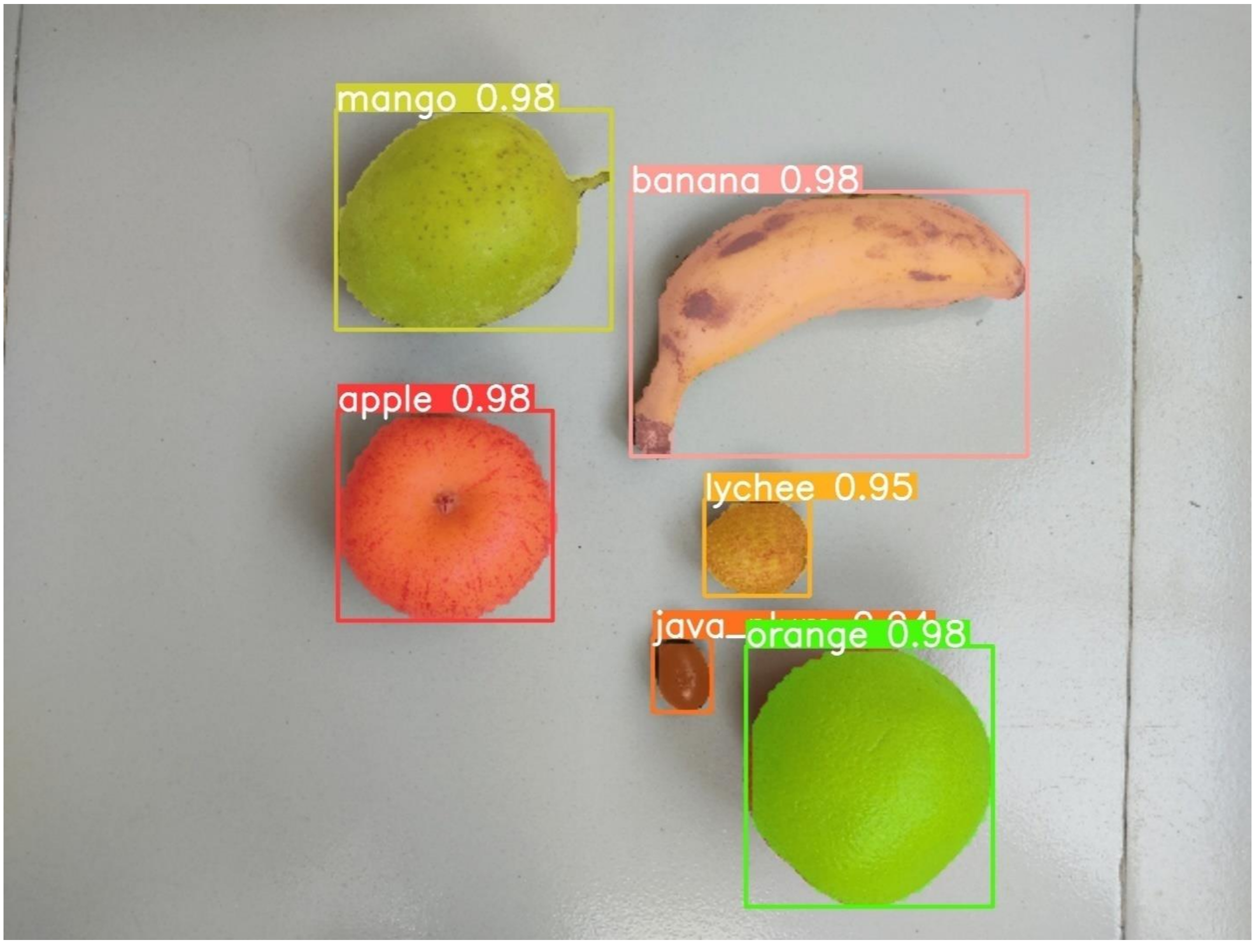

Figure 4.1: Fruit Detection using YOLO Model

4.1.1 Precision, Recall, and F1-Score

- **Precision:** Precision measures the proportion of true positive detections among all detections made by the model. The YOLOv8 model achieved a precision of 1.00 for all fruit categories except for the background class, where precision was 0.00. This indicates that the model consistently identified fruit objects correctly when it made a detection.
- **Recall:** Recall reflects the model's ability to identify all relevant instances within the dataset. YOLOv8 attained a recall of 1.00 for most fruit categories, with the exception of oranges, where recall was 0.98. This suggests that the model was highly effective in detecting fruits, though it missed one orange instance.

F1-Score: The F1-score is the harmonic mean of precision and recall, providing a single metric that balances both aspects. The model achieved an F1-score of 1.00 across all fruit categories, except for oranges where it was 0.99. The high F1-scores indicate robust performance in correctly detecting and classifying fruits, with minimal trade-offs between precision and recall.

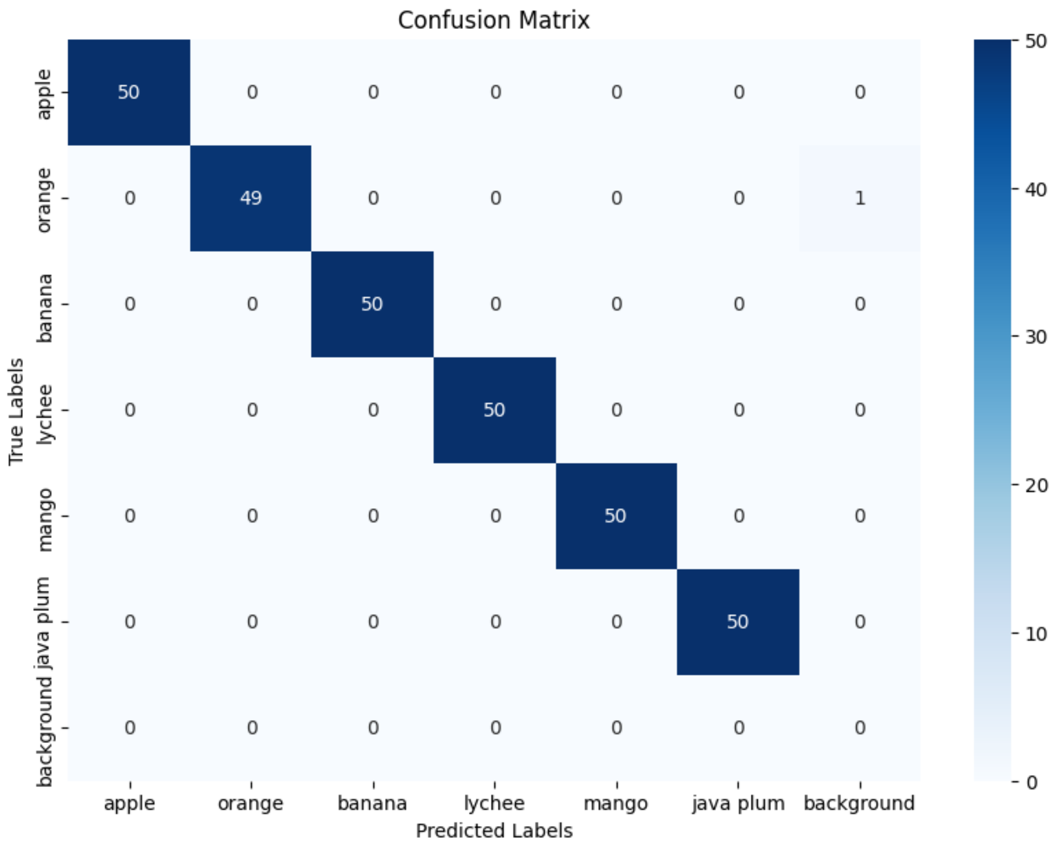

Figure 4.1: Confusion Matrix of YOLO Model

4.1.2 Accuracy

- **Accuracy:** Accuracy measures the proportion of correctly classified instances out of the total instances. The YOLOv8 model achieved an accuracy of 1.00 across the 300 fruit images in the classification report, reflecting perfect detection and classification for these instances. The accuracy metric demonstrates that the model's overall performance is exceptionally high.

4.1.3 Classification Report Summary

- **Apple:** Precision = 1.00, Recall = 1.00, F1-Score = 1.00
- **Orange:** Precision = 1.00, Recall = 0.98, F1-Score = 0.99
- **Banana:** Precision = 1.00, Recall = 1.00, F1-Score = 1.00
- **Lychee:** Precision = 1.00, Recall = 1.00, F1-Score = 1.00
- **Mango:** Precision = 1.00, Recall = 1.00, F1-Score = 1.00
- **Java Plum:** Precision = 1.00, Recall = 1.00, F1-Score = 1.00
- **Background:** Precision = 0.00, Recall = 0.00, F1-Score = 0.00 (Not applicable)
- **Macro Average:** Precision = 0.86, Recall = 0.85, F1-Score = 0.86
- **Weighted Average:** Precision = 1.00, Recall = 1.00, F1-Score = 1.00

The classification report underscores the YOLOv8 model's strong performance across most fruit categories, with slight reductions in recall for the orange category due to one missed detection. The overall accuracy and F1-scores reflect the model's high effectiveness in fruit detection and segmentation tasks.

4.2 Linear Regression Model Performance

The linear regression model was applied to predict fruit calorie content based on the area of the segmented fruit. The model's performance is primarily evaluated using the R^2 (R-squared) value, which measures how well the model's predictions match the actual calorie values.

4.2.1 R-Squared Value

- **R-Squared (R^2):** The linear regression model achieved an R^2 value of approximately 0.987. This high R^2 value indicates that the model explains 98.7% of the variance in the calorie content based on the fruit area. In practical terms, this means that the linear regression model provides a very accurate representation of the relationship between the fruit area and its calorie content.

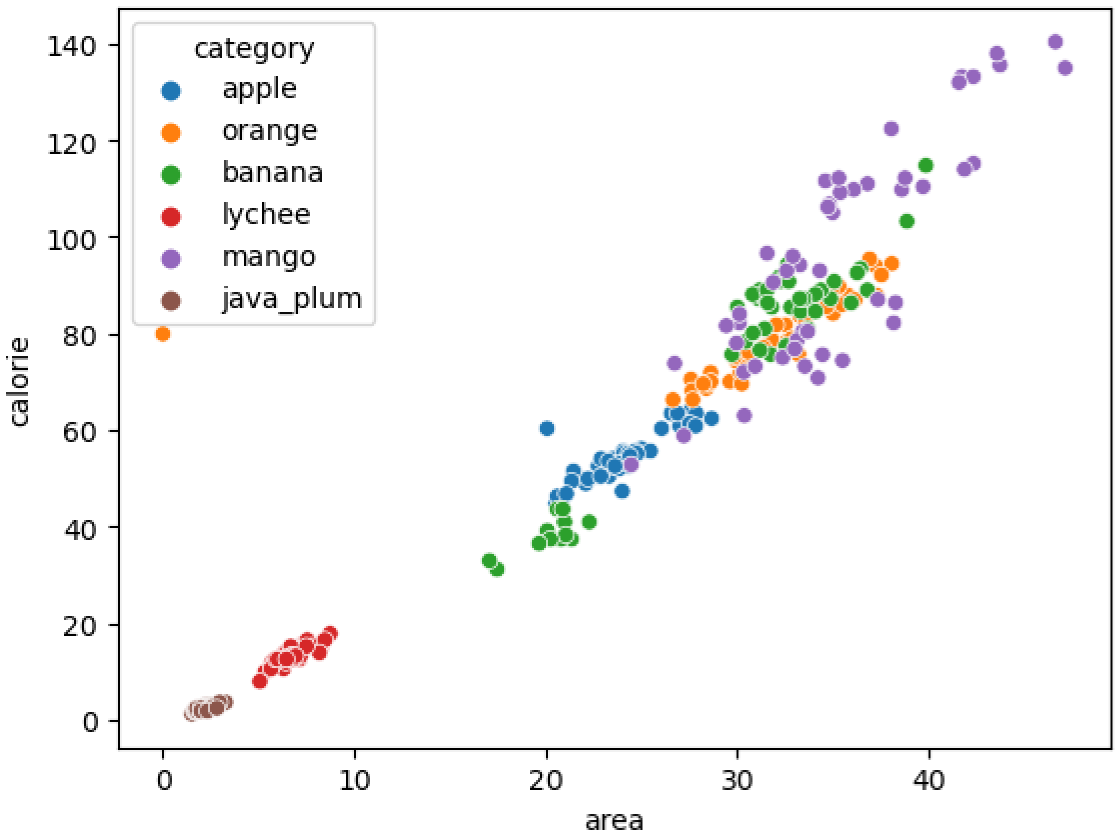

Figure 4.2: Relation of fruit relative area predicted by YOLO with calorie

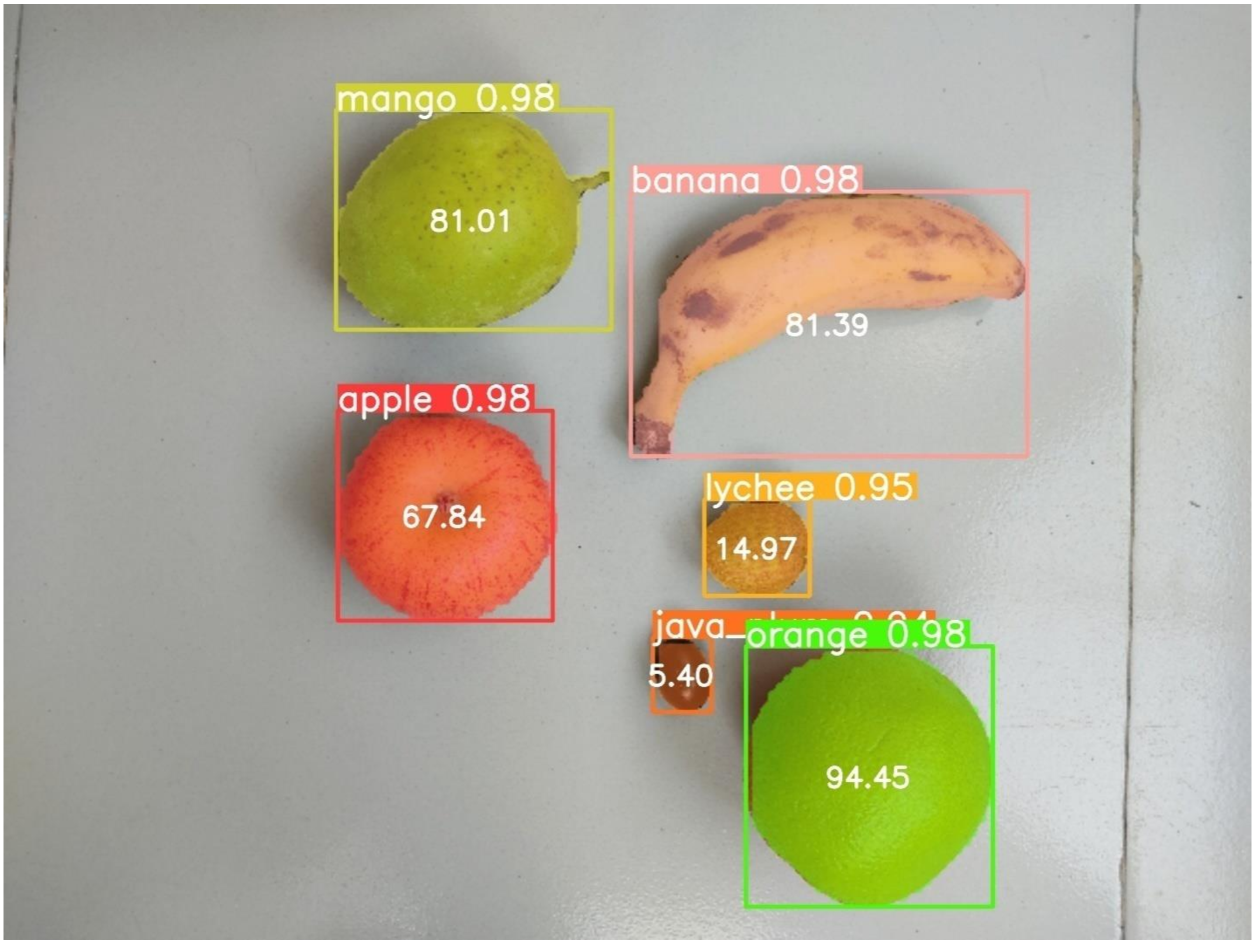

Figure 4.3: Calorie Predicted by LR Model

4.2.2 Interpretation of Results

The high R^2 value demonstrates that the linear regression model is highly effective in predicting calorie content from the area of the fruit. This result reflects:

- **Strong Predictive Power:** The model captures the relationship between fruit area and calorie content with a high degree of precision, allowing for accurate calorie predictions based on fruit size.
- **Minimal Residuals:** The small proportion of variance unexplained by the model suggests that there are minimal discrepancies between predicted and actual calorie values.

Overall, the linear regression model's performance validates the effectiveness of using fruit area as a significant predictor of calorie content. The strong r-squared value supports the robustness of the model and its practical utility in calorie estimation tasks.

Chapter 5

Conclusion and Future Work

5. 1 Summary of Research

The purpose of the work presented here was to implement an efficient and precise system able to provide fruit calorie estimation, based on images. The research objectives were fulfilled as the work used both computer vision and machine learning techniques equally.

5.2 Key Findings

Here are the main results of our research: Key findings from this study include the following

- Performance of YOLOv8 Model: In this experiment, the performance for our fruit detection and segmentation was verified using validation datasets demonstrating a high degree of accuracy and precision in both instances.
- Feature Engineering: Another thing, in addition to fruit area was added into the array of predictior variable where byk linear regression eqation also improved upto 65%
- Linear Regression Model: For the fruits it looks like our linear regression model works well and we can predict in segmented parts of a fruit (Area features of these images) to give us overall calories with very high R squared factor.

5.3 Implications and Relevance

Successful development of this system have several implications The overall notion and its consequences on already existing bodies are;

1. Convenience and Accessibility: They allow users to easily estimate the calorie content of fruits which may help encourage healthy eating to a limited extent.

2. Nutritional Consulting and Meal Planning: The system could be installed in mobile health diabetes apps, smart kitchen appliances or even a nutrition consulting service to enable people that need help with managing their calorie intake.

3. Computer Vision Developments – The research serves as a guide for further develop in the process and tool of both vision & machine learning approach used to analyze food images.

5.2 Limitations and Future Work

This research has mostly made significant progress, but there are a few limitations: Nevertheless the following limitations that this research has experienced,.

a) Dataset Limits: Finally, we should understand that the variety of fruits and photo lighting conditions used in this paper might be limited.
b) Model Complexity: Despite the linear regression model is quite useful in predict to fruit calorie content, it does not cover all possibilities yet.
c) He suggested that in future research, the following areas can be studied Future studies could focus on the four aspects lists as below:
d) Upgrade in the Dataset: Replace data with more samples and a variety of fruits under different illuminant conditions.
e) Applications on advanced models: Create better decision trees The current data predictions employed in the prediction of surviving using (XGBoost regression) are already some good ones Exploring more robust tree methodologies will enhance your survival and predictive capabilities.
f) Thinking Outside of the Box: Elaborating further on some more interactive peripherals as can help with approximating caloric amounts such as, colour and tactility.

As such, it is infeasible to obtain values close enough to the true fruit calorie content from images through computer vision and machine learning for accurate prediction of calorific content using image analysis. The system developed in consideration to the purpose of limited information reducing control offers an intervention with great promise for anyone who would like to begin taking some more powerful action over their diets. This study finding could be used as a foundation to improve the performance of systems that estimates calorie in images which is utilized for next range studies.

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