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Fruit Analysis Using Machine Learning and Deep Learning

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A B S T R A C T

This paper introduces a web-based application designed to enhance individuals' fitness habits by accurately estimating the calorie content of fruits. Leveraging machine learning techniques, the application employs a convolutional neural network (CNN) with a Tensor Flow Lite model trained on Teachable Machine, ensuring efficient fruit image recognition and calorie calculation. The CNN framework, inspired by biological processes, outperforms conventional methods, demonstrating higher accuracy in image recognition. The application captures, recognizes, and automatically calculates calories, promoting optimal fruit intake for improved health. By training the CNN model on a dataset featuring 10 different fruits, including Apple Red, Banana, Clementine, Mango, Orange, Passion Fruit, Peach, Pineapple, Walnut, and Watermelon, the paper emphasizes the nutritional benefits of fruits in preventing diseases such as cancer, diabetes, and heart conditions. The systematic approach presented here offers a valuable tool for individuals seeking to maintain a balanced and health-conscious diet

Keywords: Object Detection, Convolution Neural Network, Deep Learning, Image Recognition, Image Segmentation, Data Augmentation.

Introduction

In today's health-conscious era, the global emphasis on weight management and obesity prevention has intensified, prompting a heightened interest in consuming wholesome, low-calorie foods. Recognizing the challenges individuals face in accurately assessing their daily calorie intake, particularly concerning fruits, this research endeavors to introduce an innovative and accurate system for estimating calorie and nutritional content. In an era where obesity treatment necessitates meticulous tracking of daily food consumption, factors such as nutritional knowledge gaps, limited education, and self-discipline pose significant obstacles. To address these challenges, our proposed model aims to serve as a valuable tool for both dieticians and individuals, aiding in the precise determination of daily calorie intake and fostering healthier dietary habits.

The focal point of our endeavor is a web-based application designed to revolutionize the estimation of fruit calories, contributing to improved health and nutrition awareness. Leveraging a comprehensive image dataset, our model integrates cutting-edge techniques such as pre-processing, segmentation, and feature extraction, coupled with machine learning-based classification using shape and size attributes. The utilization of advanced image processing methods ensures accurate determination of fruit object dimensions, culminating in the precise estimation of calorie content. The application provides a user-friendly interface, empowering individuals and patients alike with informed recommendations for optimizing fruit intake and promoting overall well-being.

While recent years have witnessed a proliferation of mobile applications targeting daily meal recording, incorporating fruit image recognition for both identification and calorie estimation, they often fall short in user-friendliness. Many require manual input of information, such as fruit categories and size or volume, introducing subjectivity and inconvenience. To overcome these limitations, our research proposes an automatic fruit photo recognition system on mobile devices, eliminating the need for manual user input. Despite the strides made by CNN-based image recognition methods, achieving fully-automatic fruit calorie estimation remains a challenge addressed by our groundbreaking "fruits" dataset. This dataset, coupled with a deep neural network, promises to bridge the existing gap in fully-automatic fruit calorie estimation applications.

In summary, this research not only introduces a novel approach to fruit calorie estimation but also aims to contribute to an improved understanding of dietary behaviors for enhanced healthcare outcomes. Through the development of a sophisticated application and leveraging a comprehensive dataset, our goal is to empower individuals in making informed and healthier choices, ultimately promoting holistic well-being.

System Architecture

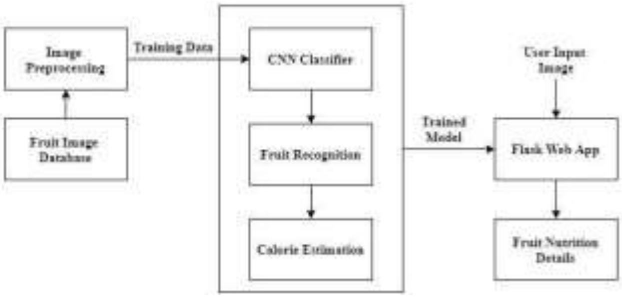

Fig 1: Block Diagram

To accomplish better area results, we will utilize a Deep Learning strategy called Convolutional Neural Network to improve the accuracy. The system architecture is given in Fig. 1 also each blockand their implementation are described in this Section.

A. Image Preprocessing:

Image Preprocessing Parameters	**Description**
Rotation	Augmentation by rotating the raw image.
Width Shift	Shifting the width of the image to create variety.
Height Shift	Shifting the height of the image for diversity.
Horizontal Flip	Flipping the image horizontally for additional samples.
Zooming	Zooming in or out on the image to enhance variation.

The image preprocessing phase involves the utilization of three distinct datasets, as illustrated in Table 3. The datasets include "Fruits 360," "Object Detection," and a customized dataset named "Fruit 123." The combined dataset is created by merging the first two datasets. Each dataset provides specific statistics on size, number of images, classes, and the labeling status.

	Size (MB	#Images	Classes	Labelling
Fruits 370	758.4	90483	131	Already labeled
Object Detection	29.82	900	15	Already labeled
Fruit 124 (Customize)	46.72	3640	5	Already labeled

The Convolutional Neural Network (CNN) employed in the project requires substantial training data for automatic feature learning. To augment the size of the data sample, various image preprocessing techniques are applied. The Keras Image Data Generator class is utilized to implement random transformations, such as rotation, width shift, height shift, horizontal flip, and zooming. These techniques result in an increased dataset size, typically expanding the existing data by a factor of approximately 3x to 4x times.

B. Neural Network Model:

The foundation of the developed model lies in deep learning, specifically employing Convolutional Neural Networks (CNN). Also referred to as ConvNets, CNNs represent a class of deep neural networks characterized by a shared-weights architecture and translation invariance properties. In the realm of deep learning, CNNs have proven to be highly effective for image-related tasks, leveraging their ability to automatically learn hierarchical features from input data. The model architecture is structured with a series of convolutional layers, each equipped with a distinct number of filters, promoting feature extraction. Incorporating Rectified Linear Unit (ReLU) activation functions, max pooling operations for spatial dimension reduction, and dropout layers to mitigate overfitting risks, the CNN model ensures a robust and efficient framework for fruit classification. The final layer, a dense layer utilizing the softmax activation function, provides probabilities for the identified fruit types in the input image. The training of the model involves an Adam optimizer and is executed over a specified number of epochs, further enhancing its ability to accurately classify fruits.

C. Fruit Segmentation:

The identification of the fruit entity is achieved through the utilization of the CNN model. In the subsequent phase, image segmentation is conducted employing the morphological functionalities of OpenCV. A blend of methodologies, encompassing canny edge detection and morphological operators, is applied to partition the fruit entity and derive the outline of the fruit.

A combination of techniques, such as canny edge detection and morphological operators like dilation, were employed to segment the food entity and extract the contour of the fruit. Segmentation based on contours is executed by evaluating the quantity of contours and identifying the most substantial contour corresponding to the fruit. Distinct sets of morphological operations necessitate repetition for various food items to adequately isolate the respective food regions.

3. Comparison Table

3.1. 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.

3.2. 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.

3.3. 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.

SL No.	Title	Authors	Advantages	Disadvantages	Accuracy
1	Fruit Classification and Calories Measurement using Machine Learning and Deep Learning	Adarkar Amol, Sharma Smriti, Bharambe Rishikesh, Gladson Roy and Satishkumar Varma	Machine learning and deep learning models can achieve high accuracy in fruit classification and calorie measurement, ensuring reliable results for dietary assessment.	The performance of these models heavily relies on the quality and representativeness of the training data.	91%
2	Classification of Fruits Using Deep Learning	Mohammed A. Alkahlout, Samy S. Abu-Naser, Azmi H. Alsaqqa, Tanseem N. Abu-Jamie	Automation streamlines the process of fruit classification and calorie measurement, saving time for both users and dieticians.	Training and maintaining deep learning models can be computationally expensive and resource-intensive.	97%
3	Fruit Image Recognition and Calorie Measurement Using Convolutional Neural Network (CNN)	Ms. Mrunali Gawande	The approach can be applied to a variety of fruits, accommodating diverse dietary preferences and nutritional requirements.	The performance of image-based models is sensitive to the quality and clarity of input images.	90%
4	Fruit Recognition System for Calorie Management	Vishnu H S, Sindhushree B, Punith A, Aishwarya K, Praveen G	The integration of these technologies into a user-friendly interface enhances accessibility for individuals and patients.	There's a risk of overfitting, where the model performs well on the training data but fails to generalize to new, unseen data.	92.6%

Fig 2. Comparison Table

4. Conclusion

This study presents a fruit detection and calorie measurement system employing Convolutional Neural Networks (CNN) and image segmentation techniques. Utilizing a custom fruit image dataset, a five-layer CNN model achieves over 90% test accuracy for identifying five fruit classes. The system, with its user-friendly interface, caters to dieticians and patients, providing nutritional information post-fruit recognition. While CNNs excel in handling nonlinear data, their computational demands should be considered. Once trained, the program demonstrates efficiency, contributing an uncomplicated and effective approach to CNN-based calorie measurement applications.

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