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Survey on Real Time Fruit Detection and Classification using Image Processing and Convolution Neural Network

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Abstract— **Fruit classification is an important task for many industrial applications. Image recognition and classification using Convolution Neural Networks (CNN) are the two popular approaches used in object recognition systems. The advancements in deep learning-based models make it possible to recognize complex images. This paper proposes an efficient CNN based method that performs fruit recognition, Raw-Ripe classification, calorie estimation and provide the count of the fruits from an input image. Machine learning model needs to be trained using data-sets. The data-set used are various image data containing different variety of fruit.**

Index Terms: **Fruit Classification, Calorie Estimation, Convolution Neural Network (CNN), Deep learning, Raspberry pi, YOLO V4, Image Processing, Image Segmentation.**

INTRODUCTION

Artificial intelligence has played a key role in new technologies as it is paving way for the world to be completely automated, with image processing and other emerging technologies object detection is being exploited to its complete potential in almost every computer vision application. This can be seen in food-based industries for fruit recognition and classification. Fruit classification is a complex problem due to all the variations that can be encountered; it opens new opportunities for researchers to address those issues. With reference to those researches, we are proposing a method for fruit detection and classification.

Aim of this paper is to identify the fruit and classify it based on its ripeness i.e., raw or ripe and to obtain the count as well as total calorie estimate of the fruits detected in a single frame. This can be accomplished based on its shape, size, texture and color. To achieve these objectives, we make use of deep learning techniques like Convolution Neural Networks (CNN) along with image processing.

LITERATURESURVEY

Analysis of visual features and classifiers for Fruit classification problem [1]: In this paper they have analyse the visual features and classifiers that contribute the most while identifying a fruit. As per this paper, mostly used features for fruit classification are color, size, width & height of fruit, texture and shape features. The proposed methodology involves following techniques: Multi-class Support Vector Machine (SVM), K nearest neighbour (KNN), Naïve Bayes Classifier (NB), Decision Trees (DT), Linear Discriminant Analysis (LDA), Feed Forward Back Propagation Neural Network (BPNN).

Advantage: The proposed algorithm is able to classify, with compatible accuracy as compared to the existing methods, a variety of similar fruit classes using color and texture features. Six widely known classifiers are used for classification and results compared. It is observed that the best results are achieved with Back Propagation Neural Network, SVM and K nearest neighbours' classifiers.

Disadvantage: The proposed algorithm is not tested for fruits in cluttered or occluded environment.

Automatic fruit recognition and counting from multiple images[2]:This paper is concerned with automatically detecting and counting any fruit in images of dense pepper plants. In this paper they describe a new method to locate and count green peppers in a cluttered complex image, using a two-step approach. In first step, the fruits are located in a single image and in a second step multiple views are combined to increase the detection rate of the fruits. The fruit recognition is performed with the help of Bag-of-Words model. The counting is performed through the plotting of images with multiple images.

Advantage: The BoW model eliminated 2/3rds of the false positives in the initial estimates and the minimum precision is 0.61. False positives can almost be eliminated.

Disadvantage: count of a plot could not be estimated using single images only. Plants were visible in a successive sequence of images, and there were multiple plants in an image. So, there was overlapping of fruits and repetitive count was seen. The number of true positives reduces and the miss detection rate can become quite high.

Fruit recognition system for calorie management [3]:In this paper they proposed a method for fruit recognition along with calorie estimation. They have proposed a method involving segmentation to exact images using color segmentation, k-mean clustering, texturing tools and selected the parts of the process of cloud SVM for fruit recognition. For calorie estimation they trained a data set with calorie table for each fruit label.

Advantage: It is able to detect the fruit accurately with precision mostly above the rate of 80%. The true positive cases are rather considerably high.

Disadvantage:Accurate calorie estimate is not obtained as the calories depend on the size and weight of the fruits. Here the datasets are rather rigid. CNN models require high performance systems and it takes more executable time to coach the signal.

Automatic fruit classification using random forest algorithm[4]: This paper proposes a method to employ fruit classification using Random Forest classifier. The aim is to achieve fruit recognition and classification based on training datasets. The proposed model applies the Random Forests (RF) classifier to recognize different kinds of fruits. The input to this stage is the fruit training data-set feature vectors with their corresponding classes, as well as the testing data-set where its output is the fruit class name for each image in the testing image data-set.

Advantage:The RF classifier is compared with KNN and obtained following results. Using shape and color as feature extraction archives the lower accuracy when classifying fruit images by KNN (71.42% orange and 72.72% strawberry) and RF (87.50% orange and 90.91% strawberry). When they run the system with 70% training and 30% testing, they achieved high accuracy y (71.42% orange and 72.72% strawberry) using SIFT as feature extraction with both KNN and SVM classifiers, where RF classifier achieves 100% accuracy when extract features by shape and color.

Disadvantage: when the training data-set is 60% and 70% testing size, orange achieves low accuracy than apple, and the highest accuracy for recognizing apple images while orange high accuracy is 65.5% when using the SVM classifier with shape and color as feature extraction.

Ripe-Unripe: Machine Learning based Ripeness Classification [5]: This paper proposes a method to classify the fruits as ripe or unripe based on the color of the fruit. They have used CNN model for recognition and classification. They process the image in three-dimension of objects as Height, width and depth. The depth is three layers to create a CSV which is used for training. Once the training is done RGB encoding is employed.

Advantage: Complete accuracy in classification of about 3-6 fruits.

Disadvantage:The implementation needs manual input of images to classify and detect the fruits.

Automatic Fruit Classification Using Deep Learning for Industrial Applications [6]: In this paper two different deep learning model architectures are used for autonomous fruit classification. First is light model of six CNN layers while the second is Fine-tuned visual group which is a 16 pre-trained DL model. Two colored image datasets are used. One is a clear fruit images and the other one is fruit images that are challenging to predict.

Advantage:The proposed models achieved excellent accuracy on both datasets.

Disadvantage:The drawback of this paper is that the proposed model can only detect the fruit class but does not give the count, ripe or raw classification and calorie estimation.

Apple fruit detection and counting using computer vision techniques[7]: This paper presents an efficient fruit counting system using computer vision techniques. The proposed system uses minimum Euclidean distance-based segmentation technique for segmenting the fruit region from the input image. Further circle overlaying is done on the fruit region and fruits are counted on the basis of the centroid of the fruit regions.

Advantage:The proposed system is able to detect as well as count the number of apples in a single image.

Disadvantage:The drawback of this paper is the system can only detect single fruit class which is applein this case and cannot classify its ripeness and its calories

Counting Apples and Orangeswith Deep Learning: A Data-Driven Approach[8]: This paper describes a fruit counting pipeline based on deep learning that accurately counts fruit.The pipeline utilizesthree methods. Aweb-based labeling framework is used to collect and store ground truth labels from human labelers in the scalable vector graphic (SVG) format. A blob detector based on convolution network extracts candidate regions in the images. A counting algorithm based on a second convolution network then estimates the number of fruits in each region. Finally, a linear regression model maps that fruit count estimate to a final fruit count.

Advantage:The propose system achieved good accuracy with short training time and performs well with a limited data set size.

Disadvantage:The drawback of this paper is it can detect and count only apples and oranges, no ripe or raw classification and no calorie estimation.

Fruit Classification and Calories Measurement using Machine Learningand Deep Learning[9]: In this paper, a web-based application for estimating fruit calories is developed by performing various methods such as pre-processing,feature extraction, segmentationand classification using shape and size with the help of machine learning techniques. By using image processing techniques, fruit dimensions are determined. Based on its dimensions, fruits are classified and calorie is estimated by training the model with the standard nutrition table.

Advantage:The CNN model was built to achieve the best test accuracy.

Disadvantage:The drawback is the model cannot classify fruit ripeness and its count.

Color Image Segmentation for Fruit Ripeness Detection: A Review[10]: In this paper, different techniques are used to detect the rate of ripeness of fruits and vegetables. This paper describes image segmentation techniques like histogram matching, clustering algorithm-based image segmentation and relative value of parameter-based segmentation these technique uses colored images of fruits and vegetables as input data to the system. In these techniques some threshold levels are set and by comparing the input data image with these threshold levels we can find the maturity level of given fruits and vegetables

Advantage: Increase in accuracy for detection of rate of ripeness of fruit by comparing other image segmentation techniques. This paper presents a simple method to find the maturity level of given fruits and vegetables

Disadvantage: Both clustering algorithm and histogram matching needs color space transform and these algorithms are used only to detect ripeness of the fruit. No count and calories of fruits can be estimated.

Automatic Fruit Detection System using Multilayer Deep Convolution Neural Network[11]: This paper presents a CNN based approach for automatic detection of fruits. The proposed system uses fruits-360 dataset which consists of 12 classes which consists of 6783 images. The method includes CNN layers, pooling layer for feature extraction and activation functions such as RELU and Softmax.

Here max pooling is used as it extracts and resizes the image better than average pooling method.

Advantage:This proposed method is to increase the accuracy for detection of fruits.

Disadvantage: This paper presents a simple method for only detection of fruits whereas it doesn't emphasize on classification of fruits.

Food Calorie Estimation using Convolutional Neural Network[12]: This paper describes a model for calorie estimation using deep learning algorithm. The authors have used ECUSTFD for food image dataset which also holds the records of food volumes and masses and it also provides labeled image. The proposed method uses TensorFlow's Object detection API to detect food items from image and also SVM and random forest methods with CNN to improve accuracy.The calorie is estimated using the formula $C = c \times \rho \times v$, where C is the estimated calorie, c is calories per gram, ρ is average density of food and v is the estimated volume.

Advantage: In this proposed CNN model the volume error estimation is gradually reduced by 20%, which indicates the increase in accuracy for estimation of calorie.

Disadvantage: It doesn't concentrate on classification of food.

Fruit Ripeness Based on RGB, HSV, HSL, L*a*b* Color Feature Using SVM[13]: The proposed paper considers a fruit ripeness dataset for 8 categories, namely Ripe Mango, Ripe Tomato, Ripe Orange, Ripe Apple, Unripe Mango, Unripe Tomato, Unripe Orange, and Unripe Apple. The model uses the SVM algorithm to predict fruit ripeness using the RGB, HSL, HSV, and L * a * b * color features contained in fruit.

Advantage: The model generated using the 6th-degree polynomial kernel with HSV color features achieves the best accuracy value of 0.76, the best precision value of 0.80, the best recall value of 0.76, and the best F-Measure value of 0.78

Disadvantage:Use of four different classifiers performing the same task makes the system more complex.

Classification of Cape Gooseberry Fruit According to its Level of Ripeness Using Machine Learning Techniques and Different Color Spaces[14]: In this paper, the combinations of four machine learning techniques like the ANN, KNN, DT, and SVM classifiers and threecolor spaces (RGB, HSV, and L*a*b*) were evaluated with regard to their ability to classify Cape gooseberry fruits. 925 Cape gooseberry fruit samples were collected, and each fruit was manually classified into one of seven different classes according to its level of ripeness

The data were first extracted from image samples to obtain feature vectors organized by each class and vector space. Then, four classification models were trained and tested using a cross-validation strategy with one hundred iterations. Finally, the results were statistically evaluated to analyze the effects of the different color spaces on the performances of the four classifiers

Advantage: The models based on the L*a*b* color space and the SVM classifier showed the highest f-measure (accuracy) regardless of the color space.

Disadvantage: The principal component analysis combination of color spaces improved the performance of the models at the expense of increased complexity.

Detection and Counting of Mango Fruits in Occluded Condition Using Image Analysis[15]: This study proposed a method for detecting and counting the number of mangos in occluded conditions by evaluating the color filter. This method performed histogram intensity threshold calculation on each RGB color channel and morphological operations for segmenting fruits object from its background. This study fully made use of the information extracted from the created blobs after conducting histogram filtering and performing a hierarchical clustering

Advantage: This method had a lower efficiency cost and did not need to determine the number of clusters to be searched

Disadvantage: The drawback of this method is the detecting and counting fruit objectcannot be done in over-exposure lighting conditions

PROPOSED METHOD & CONCLUSION

The main objective is to detect and recognize the fruit. When it comes to fruit recognition, there are many different aspects such as shape, size, texture or color. These visual features contribute most to the identification of a fruit. For fruit detection we are using Convolution Neural Network such as YOLO V4 where fruit recognition is achieved by mapping those visual features. YOLO is based on object detection and also supports object counting hence, we can provide fruit count. Fruit count can also be obtained by using image segmentation techniques such as blob detector, parameter-based segmentation. Fruit ripeness classification is achieved using image processing and color transformation where the fruits are classified as ripe or raw based on saturation level. The intensity of a particular color can be detected and its RGB values are compared to the threshold value to achieve the objective. Then calorie estimation is obtained with the help of a pre trained model.
To achieve real time application, we make use of raspberry pi along with integrated camera to capture the live data and to obtain the output via a digital screen. Model is trained with datasets. The dataset consists of different fruit images. The dataset used to train the model plays an important role to build an efficient and accurate model, more the size of the data set, more is the accuracy of the model. Variety of fruits successfully recognized depends upon the variety of fruits in the dataset.

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