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A BRIEF REVIEW ON MATURITY LEVEL ESTIMATION OF FRUITS AND VEGETABLES USING IMAGE PROCESSING TECHNIQUES

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Abstract: This paper sheds light on the advancements made in the automated agricultural industry. Digital image processing techniques are now widely used for maturity estimation of fruits and vegetables. This work aimed to study and analyze the various algorithms and feature extraction techniques that are now used for extracting features from the captured digital images. Advantages and disadvantages of various classifiers have been discussed. It was observed that for achieving high accuracy a compromise is to be made with high computational complexity.

Keywords: Color, Digital Image Processing, Maturity level, RGB, Grading.

Introduction

Fruits and vegetables play an important role in keeping the body healthy and have numerous benefits. Aroma and taste of the fruit are determined by its maturity level. Owing to lack of storage facilities in developing countries like India, huge quantity of fruits and vegetables are wasted. Therefore, there should be a method to determine the maturity level of harvested crop. In India, this task is still performed by human laborers. But the manual method used for classifying the harvested crop is very time consuming, painstaking and inefficient because human perceptions can be easily fooled. It is the need of the hour to use non-destructive maturity determination techniques for making the agricultural operations more economical. Various systems have been developed by the researchers but due to low efficiency and high cost, it is not viable to implement these systems at industrial level. So it is very crucial to analyze the advantages and disadvantages of existing systems for further developing the efficient system. Color, size and texture are key parameters for judging maturity. Quantification of these visual properties can significantly improve the agricultural management tasks.

Related work

Alfatni *et al* (2008) developed an automated grading system for oil palm bunches using the RGB color model. The purpose of the developed grading system was to differentiate the three

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different classes of oil palm fruit bunches. Different color intensities were used for determining the maturity or color ripening index. Grading system employed a computer and camera comparable with the human eye and brain to interpret the fruit images. The mean RGB values of the palm oil fruit bunch were investigated using this grading system. The program results showed that a different category of fruit bunches can be differentiated on the basis RGB intensities.

Kandi (2010) proposed a machine vision for automatic defect detection and sorting of some single-color fruits such as banana and plum. Color digital camera was used for capturing fruit images with direction of zero degree and under illuminant D65. Surface color changes in bruised parts of the object were observed with growing decay and time-aging. 3D RGB and HSV color vectors as well as a single channel like H (hue), S (saturation), V (value) and grey scale images were applied for color quantization of the object. It was observed that there was a distinct threshold in the histogram of the S channel of images which can be used for separating the object from its background. Moreover, the color change due to the defect and time-aging was correctly distinguishable in the hue channel image. The effect of illumination, gloss and shadow of 3D image processing was less noticeable for hue data as compared to saturation and value. The value of H channel was quantized to five groups based on the difference between each pixel value and the H value of a healthy object. In this manner the defect percentage can be computed and used for grading the fruits.

Khojastehnazh and *et al* (2010) developed a lemon sorting system based on color and size. The samples of different grades of lemon were positioned in front of the cameras and were calibrated off-line. The algorithm firstly extracted the fruit from the background. Then information regarding HSI color values and estimated fruit volumes was extracted and saved in a database. The final grade of the passing fruit can be determined by comparing the HSI color values with the information available in the database. This algorithm can be easily modified for grading and quality inspection of other agricultural products like cucumber and eggplant.

Sardar (2012) proposed a computer system for comparative analysis using image processing to encourage agriculture business. This algorithm detected the defects of fruits (i.e. Guava, orange, desi berry) and further graded and sorted particular fruit on the basis of surface color using the non-destructive technique. Color was the key and unique feature for determining the quality where intensity value of pixel of digital image was identified using MATLAB. A database of 50 images was used for reference. All 50 reference images were passed through

color array to calculate image intensity value in the continuous series with help of step deviation method. The new image of fruit was matched with the database and classified in to four categories i.e. unripe, partial ripe, ripe and over ripe.

Devi and Varadarajan (2013) proposed a technique using bacterial foraging optimization algorithm which has been widely known as a global optimization algorithm. This research work used combination of Advanced Bacterial Foraging Optimization Algorithm (ABFOA) approach and RGB decomposition for segmenting the infected part of fruits based on color features into various color components. The original image was decomposed into three separate planes namely red, green and blue. Improved Bacterial Foraging algorithm was used for calculating three different thresholds for three planes. The experimental results clarified the effectiveness of proposed approach for improving the segmentation quality in aspects of precision and computational time.

Jadhav and Patil (2013) proposed a fruit quality management system based on image processing. The system was developed using MATLAB software to examine the color and size related properties of the fruit. The fruit color was detected by extracting the RGB values. The canny method was used for edge detection. In order to calculate the diameter, the fruit's natural symmetry was considered. Experiments showed that this embedded grading system has the advantage of high accuracy of grading, high speed and low cost.

Syal et al (2013) presented an intelligent system for grading of jatropha fruit by its feature value extraction using fuzzy logics. The implementation was done by using MATLAB software. There were two parts of this system- first was training and the other was testing. Under the training part various features of jatropha fruit were extracted and used for defining fuzzy set rules. Under the testing section the grading of jatropha was done according to the fuzzy set rules defined in the training section.

Tomas (2014) developed an efficient algorithm for detecting and sorting mango. The external quality features of the mango were extracted from the acquired image and were used for identifying the class of the mango. Projected area, perimeter, roundedness, and percent defect were the extracted features of the mango. The size of the mango was measured in terms of projected area. An optimal threshold method was used for segmenting the desired region and boundary tracing technique was used for determining the perimeter. The combination of nearest neighbor technique and Euclidean distance was used for determining the quality of the mango since the data points cannot be easily disjointed. The size was determined by using thresholds since the data points with the same size lie closer to each other. The defective

areas of the mango were properly identified. The algorithm accurately segmented the mango even if its position was changed. This method failed to correctly identify the stem since it can be brown or green. The mangoes with green stem pixels were classified as healthy but the mangoes with brown stem pixels were classified as defective.

Mishra *et al* (2014) developed the hierarchical grading method for fruits. In this work the identification of good and bad fruits was done by using MATLAB. Various features from the input fruit image were extracted and different methods like thresholding, segmentation, k-means clustering were used for getting desired databases. Several trained databases were compared for getting a definite range of the good and bad fruits. From the proposed range identification of good and bad fruits can be done. This method can also be used to identify quality of vegetables with more accuracy.

Mohana and Prabhakar (2014) proposed a machine vision to grade the date fruits based on the combination of shape and textural features. Bilateral filter was used for reducing the specular reflection and noise. Threshold based segmentation was done for background removal and fruit part selection from the given image. Shape features were extracted using the contour of the date fruit. Curvelet transform and Local Binary Pattern (LBP) were used for extracting textural features. Lastly, combination of shape and texture features was used to grade the dates into six grades. K-Nearest Neighbour classifier yielded the best grading rate compared to other two classifiers such as Support Vector Machine (SVM) and Linear Discriminant classifiers.

Gawande and Dhande (2015) developed fruit grading and sorting system by using image processing and data classifier. The proposed system identified the infected region from the input images and classified the infected patterns according to their level of infection. According to external surface defects, the fruits were classified into low, average, medium, high, extreme high and fully infected classes. Infected fruit images were used for the experimental observations. Experimental results advocated that the proposed approach was able to correctly find out the defected part from fruit images and grade them as per their level of infection. By using KNN classifier it correctly classified the infected images and stored them in their corresponding database.

Nagpure and Joshi (2016) presented a novel technique for determining defects of cashew nuts based on color and texture features with K-Nearest Neighbor algorithm. The Support Vector Machine (SVM) was used for background elimination and color classification. The edge detection technique was employed for determining the size of the cashew nut and the texture

was determined by grey level co-occurrence matrix method. This approach thus provided a reasonable and robust solution for defect segmentation of cashew nuts.

Table 1: Analysis of existing algorithms

Year and Authors	**Proposed work**	**Advantages**	**Disadvantages**
Alfatni *et al* (2008)	Oil palm fruit bunch grading system using red, green and blue digital number.	High accuracy and efficiency	A sole criterion for grading was RGB values. Size and texture were not taken into consideration
Kandi (2010)	Automatic defect detection and grading of single-color fruits using HSV color space.	Effective segmentation of Region of Interest (ROI)	High computational complexity
Khojastehnazh and *et al* (2010)	Development of a lemon sorting system based on color and size.	Effective segmentation and this software can be easily extended to other agricultural products	High computational complexity
Sardar (2012)	A role of computer system for comparative analysis using image processing to promote agriculture business.	Less processing time	Small database
Devi and Varadarajan (2013)	Defect fruit image analysis using advanced bacterial foraging optimizing algorithm.	Highly efficient and easy to implement	Pre-mature convergence
Jadhav and Patil (2013)	A fruit quality management system based on image processing.	Immune to noisy environment	Time Consuming and hard to implement for achieving real time response.
Syal *et al* (2013)	Design and development of intelligent system for grading of jatropha fruit by its feature value extraction using fuzzy logics.	Capability to handle uncertainty	Fuzzy if-then rules are not robust
Tomas (2014)	Size properties of mangoes using image analysis.	Accurate segmentation and high efficiency	Misclassification of mangoes with brown stem pixels
Mishra *et al* (2014)	The quality identification of fruits in	Computationally fast	Hard to predict K-value

	image processing using Matlab.		
Mohana and Prabhakar (2014)	A novel technique for grading of dates using shape and texture features.	Robust and effective for large datasets	High computational cost
Gawande and Dhande (2015)	Implementation of fruits grading and sorting system by using image processing and data classifier	Simple to implement	High computational and storage cost
Nagpure and Joshi (2016)	Grading of cashew nuts on the basis of texture, color and size.	Suffers from over-fitting problem	High algorithmic complexity and extensive memory requirements

Conclusion

This work studied and analyzed the various algorithms and feature extraction techniques that are now used for extracting features from the captured digital images. Advantages and disadvantages of various classifiers have been discussed. It was observed that for achieving high accuracy a compromise is to be made with high computational complexity. Moreover, the algorithms developed by various researchers are not generic i.e. they are restricted to a particular type of fruit or vegetable. Extensive work is yet to be done to make the algorithms generic so that they can be easily extended to other agricultural crops with minor modifications in data sets and threshold values.

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