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QUALITY ANALYSIS AND CLASSIFICATION OF BANANAS USING DIGITAL IMAGE PROCESSING

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ABSTRACT

A quality inspection of banana can be done by mainly two ways: either instrumental tools or human inspectors. An interesting alternative is image processing can overcome limitations of these two techniques. Digital Image processing can classify the banana fruit with speed and accuracy. Good algorithms available in image processing which can classify banana based on their color and texture characteristics, but limitation is that they can work well on single banana. Bananas is sold in bunch of dozen and that's why it is important to analyze quality in bunch. This paper presents the technique of digital image processing to classify the banana in group or bunch with accuracy of more than 90%.

KEYWORDS: Instrumental, Inspectors, Texture, Digital Image, Dozen

INTRODUCTION

Bananas are the forth most important staple crops in the world and India is the leading country in the production of banana [1]. With increased expectations for food products of high quality and safety standards, the need for accurate, fast and objective quality determination of these characteristics in food products continues to grow. Classification of bananas is important task for banana industry. Classification of bananas can be done by basically three methods: (1) Human visual inspection; (2) Instrumental techniques; (3) Computerized image analysis techniques.

A human inspection process may be affected by external factors like: tiredness, bias, revenge or human psychological limitations where instrumental techniques give accurate measurements of colors but requirement are that the surface color must be quite uniform and removal of peel [8]. Image processing systems is good alternative for an automated, non-destructive and cost-effective technique to accomplish these requirements and offer an objective measure for color and other physical factors.

For effective classification of banana it is important to have good information about bananas properties, consumer properties, image processing ability or methods, image processing limitations, etc. Commercial standard color charts classifies bananas in following 7 different stages: Stage 1=all green, 2= green with trace of yellow, 3= more green than yellow, 4= more yellow than green, 5= yellow with trace of green, 6= full yellow, 7= full yellow with brown spots [3].

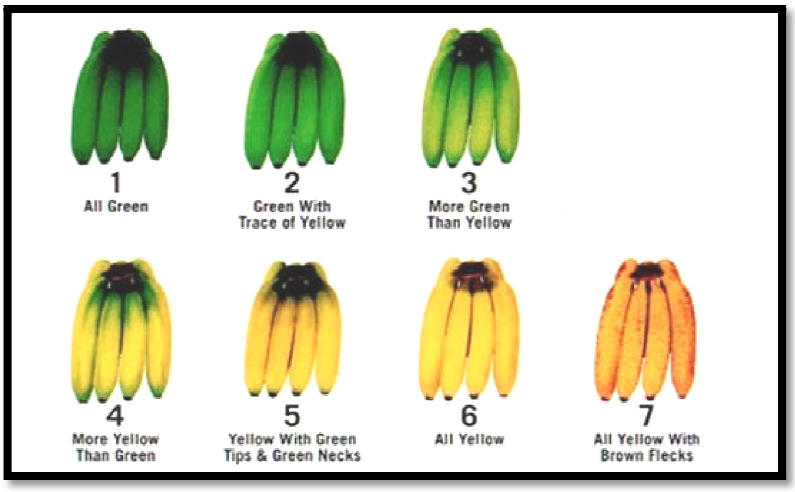

Figure 1: Seven Stage of Banana [3]

Bananas physical, chemical and mechanical properties changes will change the color of bananas so that if we can successfully measure the stage of bananas then we can get approximately right information of physical, mechanical and chemical properties. Skin color changes from green to yellow, firmness is decreased, fruit gets softened and starch is converted into sugar. A mainly color change in banana during ripening is based on the peel color rather than the pulp color and hence color of banana peel has been used in the assessment of the stages of ripeness of banana [3].

Today quality inspection of bananas in industry is mostly done by human inspectors, due to limitations of alternative methods. Mostly image processing is used for classification of other fruits and grain but bananas characteristics are different from other fruits in such a way likes: bananas always sold in group or bunch of dozen where are other fruits sold singly; bananas are important at all level, bananas have maturity stage at stage 6 and 7 but people can purchase bananas at different stage for backing use. For effective classification we must have to concern equally on bananas characteristics and consumer characteristics.

Presents Algorithm implemented on single banana that's why if any bunch contains some degraded bananas and remain are good then classifier will classify as a good quality due to average of all bananas but consumer will never goes to purchase such bunch of bananas as good quality. So that it is important to mind characteristics of consumer and analyse single bananas individually in the bunch without separating physically.

The objectives of this study were: (i) To implement a standardized computer vision system for classification of bananas by characterize quantitatively color changes during ripening using the sRGB, L*a*b* and HSV color spaces; (ii) To identify features of interest which can be related with the ripening stages such as color and textural features of the images, and; (iii) To develop a statistical model using selected features to identify the seven ripening stages of bananas from samples previously classified by expert visual inspection.

MATERIAL AND EXISTING SYSTEMS

Color Spaces

Image processing is able to measure characteristics of bananas and map to the consumer characteristics. In this section we will discuss on image processing color spaces which will be useful in classification process. To measure characteristics of bananas to classification factors following three color spaces model of image processing are important.

- RGB Color Model: The RGB (Red, Green, Blue) color model is an especially important one in digital image processing because it is used by most digital imaging devices (e.g., monitors and color cameras). In the RGB model, a color is expressed in terms that define the amounts of Red, Green and Blue light it contains.
- CIELAB color space: CIE specified color space characterized as being less illumination-dependent and the commonly used *L*a*b** or CIELAB (Robertson, 1976) [7]. *L** is the luminance or lightness component that goes from 0 (black) to 100 (white), and *a** (from green to red) and *b** (from blue to yellow) are the two chromatic components, varying from −120 to +120.

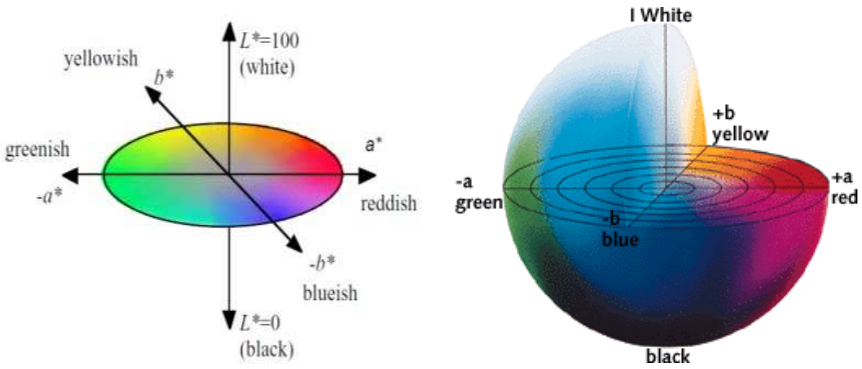

Figure 2: CIELAB Colour Space [14] [15]

The definition of *L*a*b** is based on the intermediate system CIE *XYZ* which simulates the human perception. The knowledge of these effects, such as the variations of *L**, *a**, and *b** for a particular shape of the sample could be useful for developing image processing correction algorithms which can permit a better correlation among product quality. [7]

HSV color space: The HSV (Hue, Saturation, and Value) color model describes a color in terms of how it is perceived by the human eye. This is useful when processing images to compare two colors, or for changing a color from one to another. The HSV model is also a more useful model for evaluating or measuring an object's color characteristics, such as the "yellowness" of a banana. *HSV* separates color into three components varying from 0 to 1 (when it is calculated using the function *rgb2hsv* available in Matlab);

- The *hue* (H) of a color refers to which pure color it resembles. All tints, tones and shades of red have the same hue. Hues are described by a number that specifies the position of the corresponding pure color on the color wheel, as a fraction between 0 and 1. Value 0 refers to red; 1/6 is yellow; 1/3 is green; and so forth around the color wheel.
- The *saturation* (S) of a color describes how white the color is. A pure red is fully saturated, with a saturation of 1; tints of red have saturations less than 1; and white has a saturation of 0.
- The *value* (V) of a color, also called its *lightness*, describes how dark the color is. A value of 0 is black, with increasing lightness moving away from black.

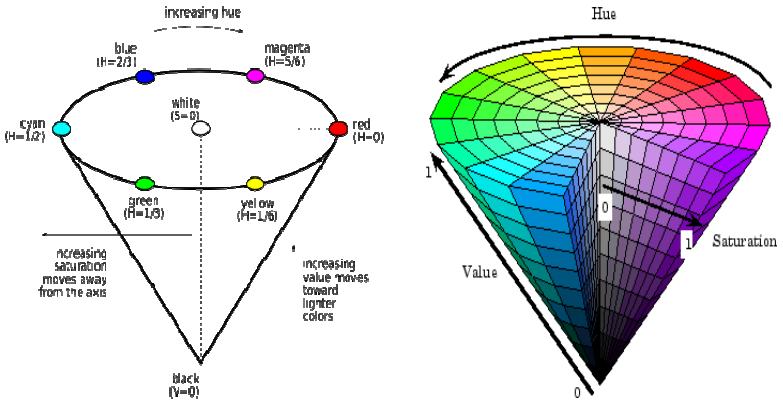

Figure 3: HSV Color Space[16][17]

This diagram, called the *single-hexcone model of color space*, can help you visualize the meaning of the H, S and V parameters.

- The outer edge of the top of the cone is the color wheel, with all the pure colors. The H parameter describes the angle around the wheel.
- The S (saturation) is zero for any color on the axis of the cone; the center of the top circle is white. An increase in the value of S corresponds to a movement away from the axis.
- The V (value or lightness) is zero for black. An increase in the value of V corresponds to a movement away from black and toward the top of the cone.

The Ostwald diagram corresponds to a slice of this cone. For example, the triangle between red, white and black is the Ostwald diagram for the varieties of red.

Existing System

Fernando Mendoza and José M. Aguilera implemented a system to identify the ripening stages of bananas based on color, development of brown spots, and image texture information. Nine simple features of appearance like: *L*a*b** values, brown area percentage, number of brown spots per cm2, extracted from images of bananas were used for classification purposes. Preliminary tests were performed to calibrate the performance of the selected parameters (i.e., *a** band and threshold of 130) in the identification and quantification of brown spots from images. Selection of features with the method of Sequential Forward Selection (SFS), Selecting *L**, *a**, *b**, %BSA and contrast permitted the correct classification of the 49 samples in different ripening stages with an accuracy of 98% [8].

F. Mendoza, P. Dejmek, J.M. Aguilera implemented a computer vision system for Predicting Ripening Stages of Bananas. Two simple color features from each image (mean value and variance of the intensity histogram of image) were extracted and analyzed using the RGB, HSV and CIELAB color spaces with classification purposes. Results show that the three evaluated sets were able to correctly predict with more than 94% the ripening stages of bananas as professional visual perception [8]. Dayanand Savakar describe in their paper of Identification and Classification of Bulk Fruits Images using Artificial Neural Networks.

The study reveals that the Classification of Chikoo is about 94% and Mango and Orange is 92% using color and texture feature sets. Classification using texture analysis is better than classification using color analysis. Best results are obtained by using the combination of both color and texture features [5].

They implemented system to predict ripening stage of bananas finger. But we have to classify bananas bunch that's why if any bunch contain multi stage bananas like some bananas at stage 4 and some at stage 5 then average of all will misclassifies to either stage 4 or stage5 based on quantity of respective stage bananas finger. According to expert if any bananas finger from bunch is in heired stage from other bananas finger than we have to classify that bananas bunch to heired stage.

METHODOLOGY

The algorithm of Bananas Classification as per given below.

Algorithm: Classification of bananas

Input: RGB color image of bananas

Output: Stage of bananas image

Start

Step 1: Read the fruit images.

Step 2: Apply segmentation methods to remove background from bananas image.

Step 3: Divides image into 8 equal parts.

Step 4: Apply below steps A to E on each parts of input RGB color image.

- Obtain the L*a*b* components for part of the input RGB color image.
- Obtain the HSV components for part of the input RGB color image.
- Find the mean value of each components of L*a*b* and HSV.
- Find %BSA component for part of input RGB color image.
- Find %Green, %Yellow, and %Brown colors in each part of input color image based on above components.

Step 5: Classify a bananas image part in to specific stage of bananas using %Green, %Yellow, and %Brown components values.

Step 6: Find maximum stage from 8 parts classified by previous step.

Stop

Above algorithm takes an image with proper size and resolution as input. Bananas are segmented from background of image for good accuracy. After that divides image into 8 equal parts and then measures parameter for every parts and compare with scale. Finally it classifies bananas based on results of all parts into different categories. Graphical representation of algorithm and methodology are discussed in next section.

Bananas classification system contain following part.

Image Acquisition

Block which contain camera, lights, and stand for banana. An image captured under following criteria will

improve result. A camera connected to PC was located vertically over the background at a distance of 40cm. A black cover was used over the sample illuminators and the Color Digital Camera (CDC) to avoid the external light and reflections. Samples were illuminated using two parallel lamps were situated 45 cm above the sample and at an angle of 45◦ to the sample. The angle between the camera lens and the lighting source axis was approximately 45◦. An image has a resolution of 1024 x 768 pixels and storage in JPEG format. The CDC was connected to the USB port of a PC to acquire the images directly from the computer.

Image Segmentation

The techniques that are used to find the region of interest (ROI) are usually referred to as segmentation techniques. We were extracting ROI of yellow, green and brown part from original image. ROI was extracted from the color image using combination of a* and b* components of CIELAB color space. Mean value of a* and b* for each color yellow, green and brown was calculated from some testing image. We were performing segmentation of those colors using mean value of respective colors. We were converting input RGB image into L*a*b* image and then calculate distance of mean value of a* and b* of input image from identical values of three colors. Based on distance from those colors we were extracting ROI.

Mean value of a* and b* used for segmentation are given in below table.

Table 1

Color	Mean Value of a*	Mean Value of b*
Green	93.2115	178.3605
Yellow	126.9776	172.5000
Brown	141.5233	153.6703
White(Background)	128.00	128.00

Mean value Segmentation Table

Features Extraction

For classification we are using following seven features: L*a*b* and HSV (Hue, Saturation and values) and % BSA. L*a*b* components extracted from RGB components using the function ‘applycform’ of Matlab. Mean value of a* and b* for each part of RGB color image are shown in above figure. HSV components are extracted from RGB components using the function ‘rgb2hsv’ of Matlab. The mean for all those 6 components are calculated and stored suitably for later usage. The brown spots on the peel of bananas were segmented from input RGB images using the combination of *a** and *b** color bands of the CIELAB color space, since the combination of these two color bands best represented the appearance and development of brown spots during ripening. This function identifies and quantifies all features in the image and sends the data to a classification system.

Classification

Classifier takes all parts component values as input and classifies bananas into different stages. Input of classifier are seven component L*a*b*, HSV, and %BSA. Using those components values classifier calculate %Green, %Yellow, %Brown color in input color bananas image. Classifier is contain set of rule of type ‘If..Then..Else’. Output is stage of bananas. To improve performance and reduce the feature we will select minimum features from seven features which will gives higher accuracy. Sequential Forward Selection (SFS) method was used for selection of minimum features for classification

Table 2

Stage	Green	Yellow	Brown
1	More than or equal to 90%	No or less than 5%	Less than 5%
2	More than or equal to 80%	less than 20%	Less than 5%
3	More than or equal to 50%	less than 40%	Less than 5%
4	Less than 50%	More than or equal to 50%	Less than 5%
5	Less than 20%	More than or equal to 80%	Less than 5%
6	No or Less than 5%	More than or equal to 90%	Less than 5%
7	No or Less than 5%	More than or equal to 75%	More than 5%

Classification Criteria Table

RESULTS AND DISCUSSIONS

Classification Performance

Bananas set are first classified by expert and based on that we create table which contain %green, % yellow, and % brown color for different stage and we compare it with input color image of bananas. Results show that using three features: L*,a*,b* we can classifies more than 92% bananas hand. Results vary for different stages. Conclusion of performance is given in table.

Table 3

Stage	No. of Sample	Performance
1	20	94%
2	15	92%
3	10	91%
4	15	90%
5	20	91%
6	30	95%
7	25	94%

Performance Index Table

Discriminant Power of Selected Features

The comparison of relationships between the selected features in each set revealed that the average values of *L** and *a** color bands and variance of *a** color band, in all the sets, presented the highest discriminating power in the predicting ripening stages. In fact, CIELAB is consider a perceptually uniform color space, and therefore more suitable for direct comparison with sensory data. It is of interest to point out that in the three evaluated sets, the most difficult stages to discriminate were between stages 4 (more yellow than green) and 5 (green tip and yellow) due to the high variability of the color data at these stages. It is important to mention that in the first stages the detection of spots in some images were due to defects on the surface of bananas. We observed that the appearance of brown spots was evident from stage 4 onwards.

CONCLUSIONS AND FUTURE WORKS

Digital image processing can improve the process of classification of bananas. All other algorithms can efficiently measure the quality of single banana but when we apply on bunch of bananas then either image acquisition setup are not suite or performances of algorithm are degrading. Based on review we can say that image acquisition is important steps over all other step. Mostly fruit classification researcher used common color space and even features are not change more. Color and texture features combination gives best result for classification process. Adding more factors for analysis will not always increase the result that’s why use of good combination of factors is important. Classify bananas in bunch will help industry to use for classification of bulk of bananas.

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