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Quality Analysis and Classification of Bananas

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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 reviews the technique of digital image processing to classify the banana in group or bunch.

Keywords— Instrumental, inspectors, texture, digital image, dozen

I. INTRODUCTION

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A. 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.

B. Problem Statement

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 we apply on bunch of bananas then we must have to change image acquisition system like: we have to set camera to the different angle, distance from sample, etc; and 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 analyze single bananas individually in the bunch without separating physically.

C. Aim of Dissertation

The objectives of this study were: (i) To select important features which can be related with the characteristics of bananas and characteristics of consumer, (iii) To develop a statistical model using selected features to identify the stages of bananas from samples previously classified by expert, and (iv) To implement an image processing system for classification of bananas using the sRGB, L*a*b* and HSV color spaces.

II. LITERATURE REVIEW

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.

A. Bananas Properties

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].

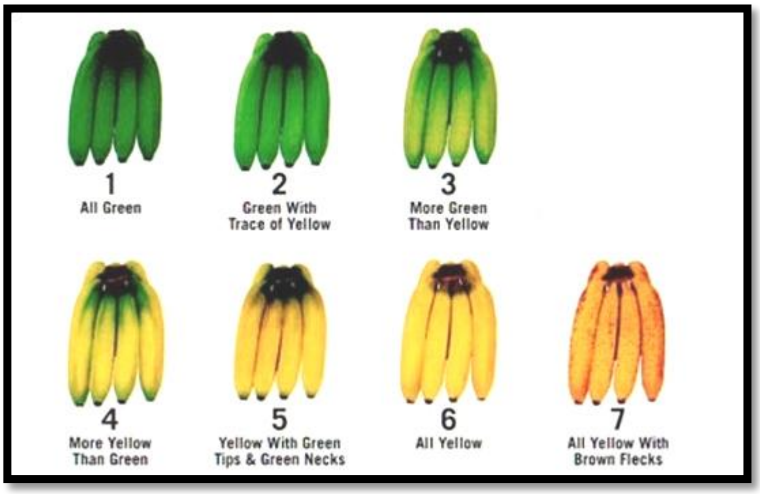

Fig. 1 Seven stage of banana [3]

- 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]. With experiment they suggested following table to get the right information about banana properties.

TABLE I CHANGES IN PHYSICAL CHARACTERISTICS IN BANANA FRUITS AT DIFFERENT STAGES OF MATURITY

Parameters	**Stage of Ripening**		
	5	**6**	**7**
Pulp/Peel Ratio	2.0	2.3	2.7
Peel Color	Yellow with Trace of Green	All Yellow	Yellow with brown spots
Pulp Color	White	White – Creamy	Yellowish Creamy

As the ripening proceed, pulp to peel ratio was increased from 2.0 in stage 5 to 2.7 in stage 7 when the fruits become fully ripened. (Table1). This could be due to the osmotic transfer of moisture from the peel to the pulp as sugar content of pulp increased. It has been suggested that pulp to peel ratio can be considered as a coefficient of ripeness. The intensity of greenness of the peel also decreased from stage 5 to stage 7.

B. Consumer Characteristics

To examine consumer purchasing behavior five characteristics are important: damage (dents and breaks in skin), markings (includes russet, waxy build-up, etc), brilliance (degree of shine), maturity/color, and one less used is bruising. The peel color of bananas is considered as the first quality parameter evaluated by consumers. Final classification after calculation of measure: All the quality measure values were summed together to create a total quality value. [6]. Development of spots expressed as %BSA (brown spots as a percentage of the total area) and NBS/cm2 (number of brown spots per cm2 of surface), changes in percentage and number of brown during ripening, etc are measures which are used in classification process [8].
According to consumer characteristics following scale table is created [6].

TABLE II SCALE RELATED TO CONSUMER PERSPECTIVE

Scale	**Fruit Appearance** (For bruising, markings, and damage)	**Standard** (brilliance)
4	Very shiny looking	Less than 10 % of the fruit on display has the negative quality characteristic present
3	Shiny looking	10 to 30 % of the fruit on display has the negative quality characteristic present
2	Glossy looking	30 to 50 % of the fruit on display has the negative quality characteristic present
1	Dull looking	Greater than 50 % of the fruit on display has the negative quality characteristic

C. 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.

1) 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 [7].
   Defines the transformation from floating point nonlinear *R`G`B`* values to sRGB:
   The nonlinear R`G`B` values are transformed to linear sRGB values by

   If R`, G`, B` ≤ 0.04045

$$sR = \frac{R`}{12.92},\ sG = \frac{G`}{12.92},\ sB = \frac{B`}{12.92}$$

   else if R`, G`, B`>0.04045

$$sR = -\left(\frac{-R`+0.055}{1.055}\right)^{2.4},$$
$$sG = -\left(\frac{-G`+0.055}{1.055}\right)^{2.4},$$
$$sB = -\left(\frac{-B`+0.055}{1.055}\right)^{2.4}$$

2) CIELAB and CIEXYZ color space: Color plays a major role in the assessment of external quality in food industries and food engineering research (Segnini et al., 1999; Abdullah et al., 2001). Color is basically specified by the geometry and spectral distributions of three elements: [i] the light source, [ii] the reflectivity of the sample, and [iii] the visual sensitivity of observer. 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. 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].

   Defines the transformation from sRGB values to CIEXYZ:

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix} = \begin{bmatrix} 0.4124 & 0.3576 & 0.1805 \\ 0.2126 & 0.7152 & 0.0722 \\ 0.0193 & 0.1192 & 0.9505 \end{bmatrix} \begin{bmatrix} sR \\ sG \\ sB \end{bmatrix}$$

   Defines the transformation from CIEXYZ to CIELAB :

$$L^* = 116\ f\left(\frac{Y}{Yn}\right) - 16$$

$$a^* = 500\ \left[f\left(\frac{X}{Xn}\right) - f\left(\frac{Y}{Yn}\right)\right]$$

$$b^* = 200\ \left[f\left(\frac{Y}{Yn}\right) - f\left(\frac{Z}{Zn}\right)\right]$$

   Where

$$f(q) = \begin{cases} q^{\frac{1}{3}} \text{ if } q > 0.008856 \\ 7.787q + \frac{16}{16} \ \text{ otherwise} \end{cases}$$

   Xn, Yn, and Zn correspond to the XYZ values of a reference white chart (qϵ{X/Xn, Y/Yn, Z/Zn}).

   The total color difference between two color in L*, a* and b* coordinates may be evaluated as

$$\Delta E^*_{ab} = \left[(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2\right]^{1/2}$$

3) 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 [7].

HSV separates color into three components varying from 0 to 1; *H* (hue) refers to the dominant wavelength perceived as different colors, such as red, yellow, green and blue, *S* (saturation) refers to how much such wavelength is concentrated and it is equivalent to the concentration of a solute in a chemical solution; and *V* (value) represents the total brightness, similar to *L** [7]. Some author use intensity (I) instead of value.

Defines the transformation from sRGB to HSV :

$$V = \max(R, G, B)$$

$$S = \frac{V - \min(R,G,B)}{V}$$

$$H = \begin{cases} 1 + \frac{G-B}{V-\min(R,G,B)} & \text{for } V = R \\ 2 + \frac{B-R}{V-\min(R,G,B)} & \text{for } V = G \\ 3 + \frac{R-G}{V-\min(R,G,B)} & \text{for } V = B \end{cases}$$

Fernando Mendozaa, Petr Dejmek, and Jos´e M. Aguilera implemented system to quantify standard color of fruit and vegetables in *sRGB*, *HSV* and *L*a*b** color spaces. The results show that *sRGB* standard (linear signals) was efficient to define the mapping between *R`G`B`* (no-linear signals) from the CCD camera and a device-independent system such as CIE *XYZ*. *L*a*b** system is suggested as the best color space for quantification in foods with curved surfaces [7].

D. 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 (Segnini, 1999) [8].

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 [8].

III. EXISTING SYSTEM

A. Fernando Mendoza and José M. Aguilera implemented a computer vision 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].

Discriminant functions used for classification of bananas:

Function 1 = -*a** - 0.65 *b** + 0.09 *L** + 0.08 %BSA + 0.15 Contrast

Function 2 = -0.07 *a** - 1.35 *b** + 0.82 *L** + 0.72 %BSA + 0.48 Contrast

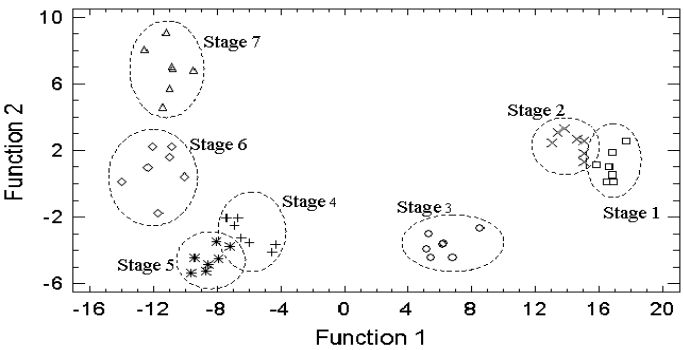

Fig. 3: Mapping of function to stage of bananas

B. Paper presents an identification and classification of different types of bulk fruit images using artificial neural networks. The color and texture features are extracted considering the whole image for feature extraction. The extracted features are stored in the form of knowledge base. When a new image is encountered features are extracted from fruit image sample. The extracted features are used to identify and classify using Neural Network [5].

Algorithm:
Algorithm 1: Identification and **c**lassification of fruit image samples
Input: Original 24-bit color image
Output: Classified fruit image of different types
Start
Step1: Read the fruit images.
Step2: Extract color and texture features.
Step3: Use these features to identify and classify the fruit image samples
Stop
Algorithm 1 is takes 24-bit color image as input and extract color and texture features of fruits based on that classifies fruits.
Algorithm 2: Color feature extraction
Input: Original 24-bit color image.
Output: 18 color features.
Start
Step 1: Separate the RGB components from the original 24-bit input color image.
Step 2: Obtain the HSV components from RGB components.
Step 3: Find the mean, variance, and range for each RGB and HSV components.
Stop.
Algorithm 2 is takes 24-bit color image of fruits as input, and extracts RGB and HSV components and mean, variance, and range or each RGB and HSV component.
The study reveals that the Classification process best results are obtained by using the combination of both color and texture features [5].

IV. BANANAS CLASSIFICATION SYSTEM

Bananas classification process contains mainly five steps as follow.

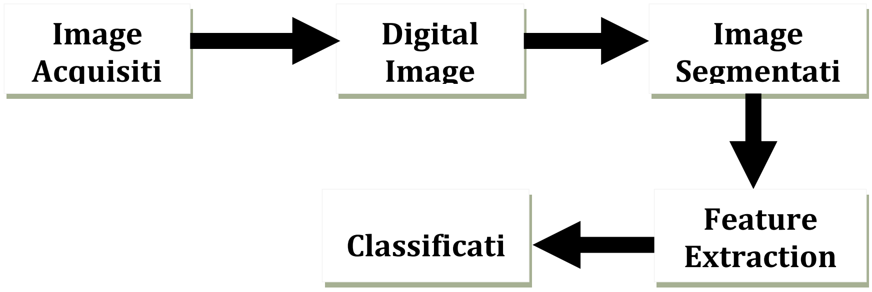

Fig. 4 Process of classification of banana

A. Image acquisition

Block which contain camera, lights, and stand for banana. Images from one side of the bananas were taken and storage in JPEG format. The camera was connected to the USB port of a PC to acquire the images directly from the computer. Image acquisition system setup is shown in below figure.

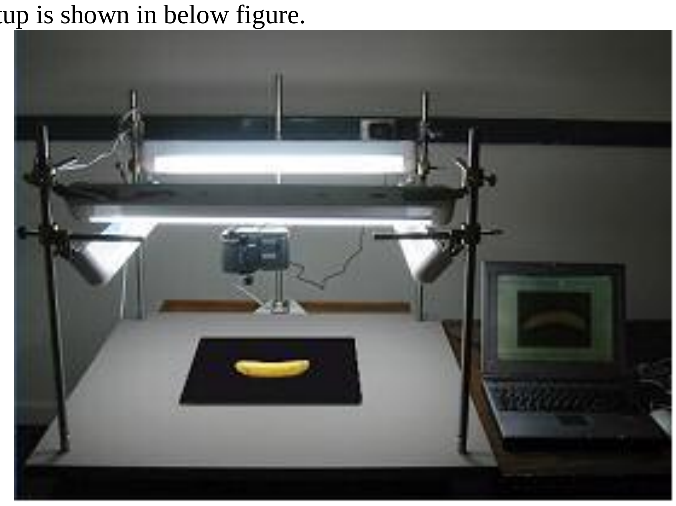

Fig. 5 Image acquisition system [8]

A Color Digital Camera (CDC) was located vertically over the sample at a distance of 22 cm. The angle between the camera lens and the lighting source axis was approximately 45º [8]. If we use this image acquisition system for bunch of bananas than because of camera was located vertically at a small distance over the sample and large size of bananas we cannot get complete image of bunch of bananas. So that it is important to change distance of camera from sample and angle of camera.

B. Digital Image

Digital images are one of the most key medium of conveying information. Extracting the information from images and understanding them such that the extracted information can be used for several tasks is an important characteristic. Convert image into digital form for the further processing. If we are use digital camera then the image is in digital form and we did not need conversion otherwise this step is required.

C. Image Segmentation

The techniques that are used to find the objects of interest are usually referred to as segmentation techniques [9].

D.Surya Prabha and J.Satheesh Kumar describes in their research [4]. They have developed a new method for better segmentation and categorization of banana fruits. Result shows better accuracy of proposed algorithm compared to other segmentation methods like: Thresoloding, Clustering, color image segmentation. Hybrid segmentation method improves results by combing edge based and region based segmentation [4].

In this research we successfully segment banana different part like brown sport, dents and breaks in skin, etc, but at industry level it has no advantage because these are end up with unimportant results means what to do after segment, we will do not apply any treatment on its and it’s takes more times compare to Thresoloding method. That’s comparing to use complex hybrid system for segment; simple Thresoloding method is more suitable for bananas classification. Fernando Mendoza and José M. Aguilera used combination of threshold of 50 with an edge detection technique based on the Laplacian-of-Gauss (LoG) operator to remove background from grayscale image. The brown spots on the peel of bananas were segmented from binary images using the combination of a^* and b^* color bands of the CIELAB color space. Images were binarized using threshold values of $a^*<140$ or $b^*>156$ (for a^* and b^* values ranging from 0 to 255) [8].

D. Feature extraction

The RGB components are separated from the original image, and the L* a* b* and HSV components are extracted from RGB components. The mean, variance and range for all these 6 components are calculated and stored suitably for later usage [4]. This function identifies and quantifies all features in the image and sends the data to a control program.

E. Classification

Classification is the process of reducing images to usable information. This meant to predict the ripening stages of bananas previously classified by expert visual inspection using the smaller number of best features extracted from the images. [8]. Based on all parts factors value bananas are classified into different class or grade. Classification process can be improved by adding more factors in the process.

V. CONCLUSIONS

Digital image processing can improve the process of classification of bananas. All reviewed and currently available 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.

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