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Apple Quality Inspection Based on RGB Color Space Using Machine Vision

Ajay Pal Singh Chauhan[+]

ECE Department, SLIET, Longowal, India

Abstract. Apple and other fruits can be valued by their appearance. The color of apple is a parameter that describes its ripeness, defects, etc. Major problem in apple grading is sorting and classification. Inspection based on human vision taking color and size attributes are considered in traditional methods. Quality decisions can be best judged on the basis of apple color as Color contains main information about fruit status. An appropriate color classification can lead to system accuracy and further lead to efficient grading. Machine vision system uses basic features such as color, size, shape etc to inspect fruit quality. The aim of this research paper is to develop a system that inspects apple on the basis of color of a tested sample

Keywords: RGB color space, color histogram, average and standard deviation, machine vision, vision builder, inspection logic design.

1. Introduction

Color attribute of apple is an important parameter in the inspection of its quality [1]. In quality inspection, effect of the background color and color intensity are the main sources of error as human eye is adapted to minute changes in color. So, it is difficult to provide a sharp quality mark line for visual inspection of fruits based on color. Depending upon an application, a particular color space is used. Though computers interpret color as a combination of red, green, and blue but humans interpret color according to parameters such as brightness, hue, and intensity. RGB color model represents the image in three separate coordinates RED, GREEN and BLUE. Apple quality can be decided on the basis of these color components present in the apple image [2].

2. Materials and Methods

A *machine vision* system allows a computer to detect with senses and assess images [3]-[5]. M*achine vision* system accomplishes this with digital cameras and back-end processing [6].

Color space permits to represent a color. Basically it's a subspace within a three-dimensional coordinate system with a point representing each color. List of customary color spaces used is as given below [7]:

- RGB—Build on red, green, and blue.
- HSL— Build on hue, saturation, and luminance.
- CIE— Build on brightness, hue, and colorfulness.
- CMY— Build on cyan, magenta, and yellow.
- YIQ—Differentiate luminance information (Y) from color information (I and Q).

Image Analysis: With image analysis, useful information is extracted from digital images employing measurements based on the gray level intensities of the pixels.

[+] Corresponding author.
E-mail address: ajaypal@sliet.ac.in

Histogram: The histogram is basically a graphical representation of interpretation of color distribution in the image.

Histogram of Color Images: Color histogram is a representation of the spread of colors in an image [8].

3. Implementation of System

System Structure

A system for inspection of apple quality is designed which consists of following main parts;

i. Computer System
   a. Hardware for camera (NI Image acquisition card)
   b. Hardware for motion control (NI Motion control card)
ii. Color Camera (IEEE Standard)
iii. Lighting and Control
iv. Inspection Base Table
   a. Shift conveyer system
   b. Disk rotation system

The system structure is designed for experimental purpose only and for industrial purpose we need some modification in the system structure and controls. The system structure is shown in Fig. 1.

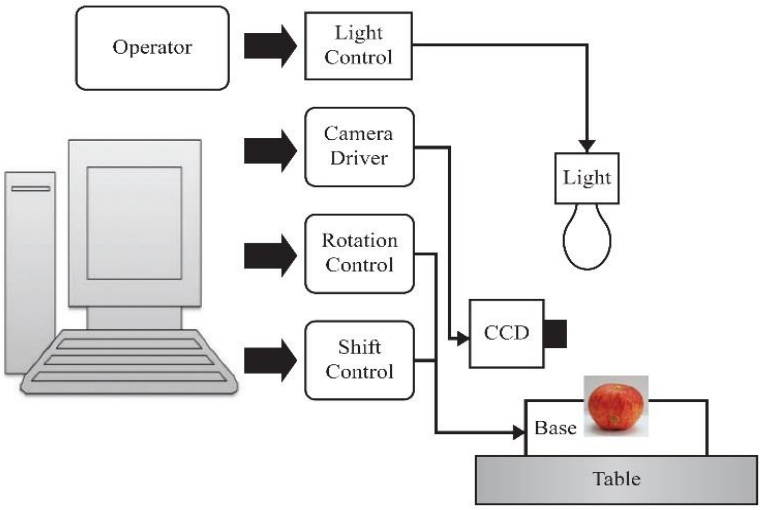

Fig. 1: System structure.

Flow Chart

The inspection process is shown in flow chart given in Fig. 2.

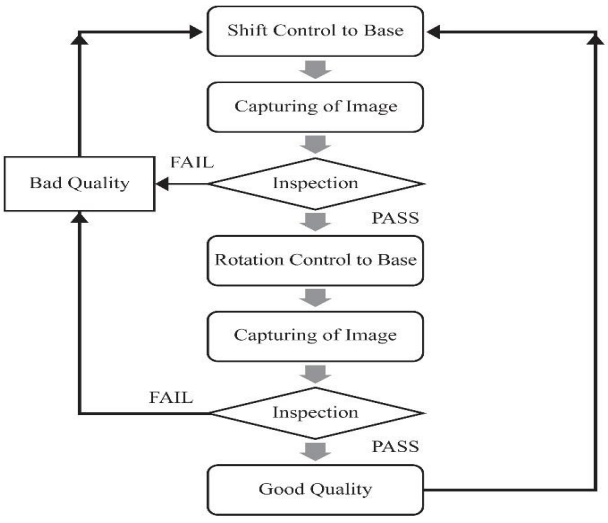

Fig. 2: Flow chart for Inspection.

In this inspection process, each apple is placed on conveyer system and by shift control it reaches the rotation disk where it will be inspected. Next step is capturing the image for inspection. This image is inspected on the basis of certain parameters according to the logic designed for inspection. If the image passes the first inspection, rotation system rotates the apple by certain angle and again inspects it. If it again passes the inspection then apple is of good quality.

4. Fruits Color Analysis Based on Histogram

In the RGB color space, every individual color component of the color image, namely Red, Green and Blue has its own histogram. Thus, the percentage composition of every individual color component, which a fruit possesses, is to be evaluated. Using this percentage composition the level for a component can be set as a standard in classifying the apples based on a particular color orientation [2], [3], [7]. Apple with higher RED percentage composition is assigned the superior grade, the next lower composition the second grade & likewise the descending grades were assigned. This enabled the sorting of apples based on the color as a parameter [6].

Image 1 Image 2 Image 3

Fig. 3: Sample images of apple.

In Fig. 3 three apples are shown and the measurement of color average and its standard deviation are given in table I. By carefully analyzing, it is found that the good quality apple contains higher average value along with lower standard deviation value of RED color. So average value and standard deviation value both can be taken as parameters for inspection. For designing the inspection logic, value of more than 100 images are analyzed and compared.

Table 1: RGB color values of images

Image No	**1**			**2**			**3**		
Parameter	**Red**	**Green**	**Blue**	**Red**	**Green**	**Blue**	**Red**	**Green**	**Blue**
Mean Value	134.4547	92.02182	84.14578	133.1442	98.89304	92.02352	131.5195	103.5372	96.39378
Standard Deviation	23.69415	55.20194	60.97743	23.72916	54.49969	61.09461	23.4752	50.34051	57.67795

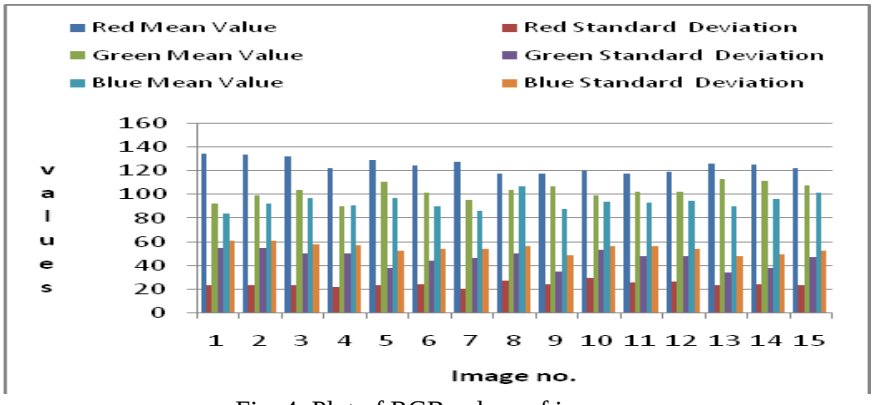

Fig. 4: Plot of RGB values of images.

In Fig. 4, comparison of 15 image values are shown, which can be used to find the cutoff value of the parameters. For inspection purpose a range of parameters are defined and if the value of inspected image lies between this ranges than output of inspection logic is ‘True’ otherwise it is ‘False.

4. Implementation of Method

Vision Builder:-National Instruments Vision Builder for Automated Inspection (Vision Builder AI) is configurable software for building [8], bench marking, and deploying machine vision applications. Inspection Steps:

1. Image acquisition

The Acquire Images [8] tab contains several acquisition steps that can be used to acquire images from different types of cameras. Here we are using single camera for image acquisition.

2. Color Histogram measurement

The acquired image is processed for the measurement of color space. This gives the image color in terms of Average value and Standard Deviation value.This measurement depends upon the color space on which the inspection logic is designed. Here R G B color space is being used for the inspection. Fig.5 shows the measurement of color space.

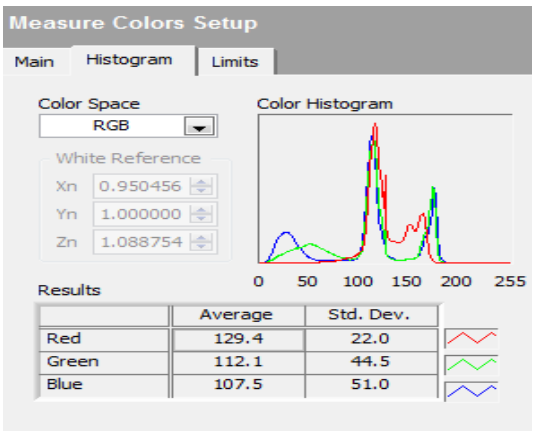

Fig. 5: Color histogram.

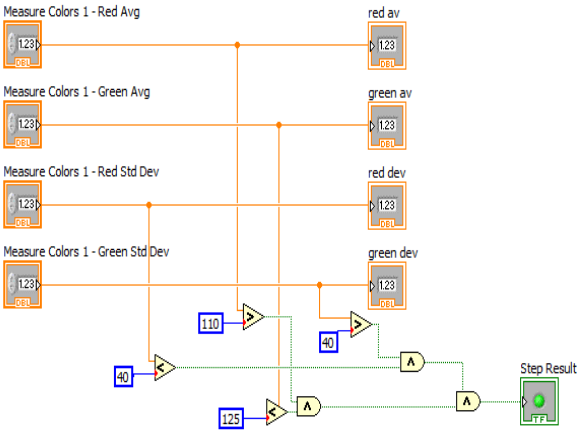

Fig. 6: Logic calculator.

3. Logic design for inspection

The inspection logic is designed on the basis of data analyzed as given in fig.4. The cut-off values of color space are decided for a good quality apple and these values are compared with inspected image values. The outputs of these comparators are logic '0' or '1's and are then fed to 'AND' logic operator for the inspection. If the outcome of all logics is 'True' then our image passes the inspection otherwise if any one outcome is 'False' then image fails in the inspection. Fig.6 shows the logic design for the inspection process.

4. Measurements from inspection logic and development of final system

As shown in Fig. 7, the Main window displays the measured inputs with resultant outputs as specified in the logic calculator. The diagram also contains a default Boolean result, named Step Result shown in Fig. 8.The final inspection system is shown in Fig. 9.

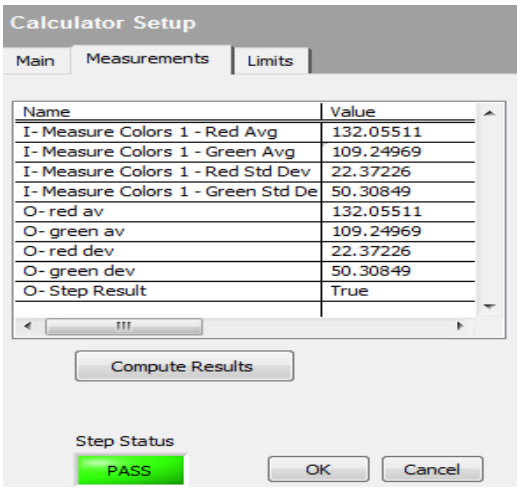

Fig.7: Computation of result.

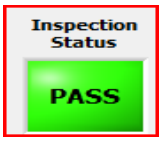

Fig. 8: inspection result.

Fig. 9: Inspection system.

5. Results and Discussion

The conventional inspection processes are designed on the basis of RED color value in RGB color space [6]. In these inspection systems average value and standard deviation of RGB are considered as inspection parameter. For deciding the cutoff values in the inspection process it is required to analyze the samples of apple. Depending upon the values of good quality apple and the lower quality apple, the cutoff values are decided. In figure 10 some good quality and lower quality apples are shown. All these images are analyzed in the inspection system and corresponding values are shown in Fig. 11. The quality of apple is decided on the basis of RED content present in image and lower quality is decided on the basis of GREN content. On this basis, image 1-4 are good quality samples and rest are lower quality samples due to presence of GREEN color in image. In Fig. 11 the correspondingvalues of average and standard deviation are plotted. By careful observation of the values of good quality apples the cutoff values can be decided.

Image1 Image2 Image3 Image4 Image5 Image6 Image7 Image8

Image9 Image10 Image11 Image12 Image13 Image14 Image15

Fig.10: Sample of apples.

In previous inspection system the average value and standard deviation of only RED component are considered as inspection parameter [5]. On the basis of RED average value of good quality apple, the cutoff value is 120. This system will pass some lower quality apples because these apples contain the cutoff values of RED with average greater than 120 for images 5,6,7,13,14 and 15. So inspection on the basis of only RED value parameter gives poor result.

For improving the inspection, it is required to consider the values of GREEN color as an inspection parameter along with RED. In table II, the values of images 1-4 are analyzed for finding the cut off values for GREEN average and standard deviation values.

Table 2: Cutoff vales

cut-off values	
Mean Value(R)	> 120
Standard Deviation(R)	<25
Mean Value(G)	<105
Standard Deviation(G)	>48

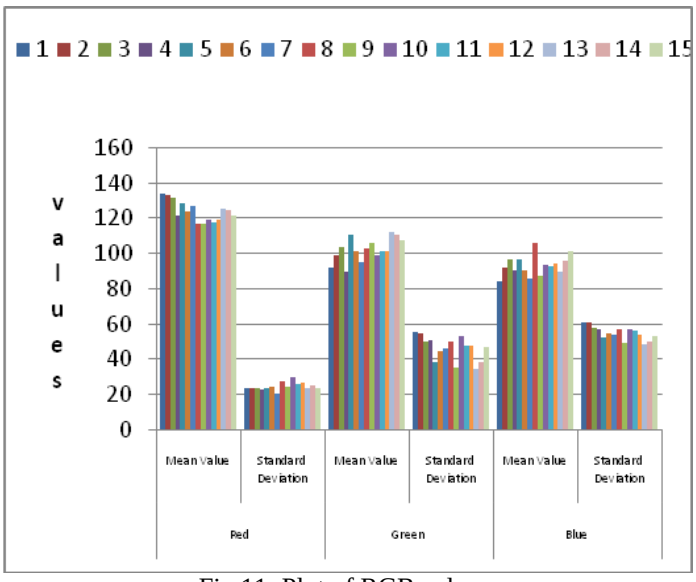

Fig.11: Plot of RGB values.

Analysis of data using MATLAB:

The obtained data are further analyzed using MATLAB for finding the improvement in inspection. For this, the same inspection logic has been implemented using MATLAB. The MATLAB script gives following outputs:

Table 3: Analysis of data using MATLAB

Inspection using	Image number that Passed inspection	Percentage Yield
Red Average And Standard Deviation	1 2 3 4 5 6 7 13 14 15	66.666667
Red and Green Average With Red Standard Deviation	1 2 3 4 6 7	40
Red and green average & standard deviation	1 2 3 4	26.666667
Percentage improvement in quality inspection of apple using 3rd method		a) as compared to 1st method= 40 b) as compared to 2nd method= 13.333

6. Conclusion

The proposed inspection system is based on RGB color space. The inspection parameter includes average value and standard deviation of RED and GREEN color. By considering these parameters the inspection results are improved as compared with previous inspection methods. In this system the value of BLUE color component are not used as inspection parameter due to fixed illumination source. When illumination source varies in terms of intensity and frequency, the BLUE component has considerable effect. The proposed system will decrease the development cost and will give the precise results.

7. References

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