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Fruits Sorting and Grading Based on Color and Size

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Abstract: Color and Size grading of fruits is very crucial steps for fruits processing that directly affects profitability, because the quality of agricultural products is often associated with their Color and Size. So many color grading techniques are available for color quality based on predefined and reference in three dimensional plane of color space. In direct color mapping, the three dimensional color space is converted into one dimensional color space. In this technique only interested color is preferred for convert into unique set of color space for respected application. For size grading, region of fruit is analysed by normalized second central moment.

Keywords: Image processing, automatic color grading, color space conversion, fruit quality, Shape identification, Region analysis

I. Introduction

Agriculture is one of the largest economic sectors and it plays the major role in economic development of India. Still in India, the traditional inspection of fruits is performed by human experts, which is considered to be time consuming and subjective. With the advent of fast and high precision machine vision technologies, automation of the grading process is expected to reduce labour cost also improving the efficiency and accuracy of the process. A computer vision system processes images acquired from an electronic camera, which is like the human vision system where the brain processes images derived from the eyes. Computer vision has been used for quality inspection of fruits. Quality inspections of fruits have two different objectives: quality evaluation and defect finding. In recent years, computer machine vision and image processing techniques have been found increasingly useful in the fruit industry, especially for applications in quality inspection and shape sorting.

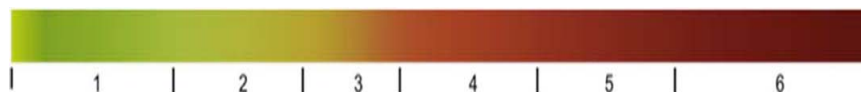
Two main characteristics are decisive for visual inspection and classification of fruits: color and shape. An efficient autonomous system for fruit sorting must be able to adequately identify both parameters. Fruit's shape can easily be obtained from a digital image using classical techniques for image processing. However, although apparently immediate for humans, color identification involves many physical and psychological concepts, making it difficult to properly model and process color in an image.

There are wide varieties of color systems present for the grading of fruits based on colors. There are some techniques like Fuzzy logic [1], Neural Network [2], Based on Color Histogram, Genetic algorithm etc. For real-time machine level application above techniques are difficult to deploy. For easy and simple technique is developed in [3] which is direct color mapping of present colors in fruits. In Direct color mapping technique RGB color space is used. Where the 3 dimensional RGB color space is converted into a small set of color indices unique to the application. Similarly for shape grading system normalized second central moments [4] of the region is used. In this paper, we are explaining how direct color mapping technique is implemented for grading of fruits based color. And also explain second order normalized second central moments of the region for shape grading. Details steps are given in the coming section.

II. Color grading

For color grading, here Direct Color mapping technique is used. In direct color mapping RGB color space is used for representation. For tomato maturity evaluation, the application for which we present experimental results, colors of interest range from dark green to dark red, with green, orange, pink, and light red in between, as shown in Fig. 1. These colors are presented during ripening stages of tomato. Only these color interested color for sorting and grading of fruits.

Figure 1 A color bar of colors of interest for tomato color grading.



A. Direct Color mapping

For every fruit there respected colour range is present. Each color of interest in the fruits color range has its own unique RGB value. So we didn't require the total 3D color space. By mapping the range of colors of interest to a 1-D color space that uses a single value or index to represent each color in the specified range such that increasing values.

The formula for conversion is given bellow,

$$\text{color index} = c_1 \cdot RGB + c_2 \cdot R^2 + c_3 \cdot G^2 + c_4 \cdot B^2 + c_5 \cdot RG + c_6 \cdot RB + c_7 \cdot GB + c_8 \cdot R + c_9 \cdot G + c_{10} \cdot B + c_{11} \quad (1)$$

Where color index shows the unique value of color which is present

B. Calibration

There are a total 11 coefficients, $C_1, C_2, C_3, \dots, C_{11}$, must be specified to use formula of conversion. These coefficients are obtained through calibration using a selected set of colors of interest in RGB values and a set of desired linear color indices.

A set of preselected colors of interest must be used to calculate the coefficients. At least 11 sample colors selected from the application's color range are needed to solve for the 11 coefficients. To determine the coefficient following matrix equation is used.

$$\begin{bmatrix} R_1 G_1 B_1 & R_1^2 & G_1^2 & B_1^2 & R_1 G_1 & R_1 B_1 & G_1 B_1 & R_1 & G_1 & B_1 & 1 \\ R_2 G_2 B_2 & R_2^2 & G_2^2 & B_2^2 & R_2 G_2 & R_2 B_2 & G_2 B_2 & R_2 & G_2 & B_2 & 1 \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ R_n G_n B_n & R_n^2 & G_n^2 & B_n^2 & R_n G_n & R_n B_n & G_n B_n & R_n & G_n & B_n & 1 \end{bmatrix} \begin{bmatrix} C_1 \\ C_2 \\ \vdots \\ C_{11} \end{bmatrix} = \begin{bmatrix} v_1 \\ v_2 \\ \vdots \\ v_n \end{bmatrix} \quad (2)$$

Where

R_i, G_i, B_i for $i = 1, 2, \dots, n$ – RGB values of preselected n color samples

$v_1, v_2, v_3, \dots, v_n$ – Desired linear color indices

n – preselected Samples

III. Size Grading

Size and Shape calculation of Fruits is done by using normalized second central moments for the region. For shape identification, major axis, minor axis and area of fruits are calculated.

A. Area calculation

The actual number of pixels in the region is calculated. For area calculation we are count number of ON pixels in the image.

B. Major and Minor axis calculation

Region-based analysis exploits both boundary and interior pixels of an object. We denote the set of pixels in a region by R . The simplest geometric properties are the region's area A and centroid $(\bar{r}, \bar{c})$ by considering ellipse shape.

Area:

The area is just a count of the pixels in the region R .

$$A = \sum_{(r,c) \in R} 1 \quad (3)$$

Centroid:

The centroid $(\bar{r}, \bar{c})$ is thus the average location of the pixels in the set R .

$$\bar{r} = \frac{1}{A} \sum_{(r,c) \in R} r \quad (4)$$

$$\bar{c} = \frac{1}{A} \sum_{(r,c) \in R} c \quad (5)$$

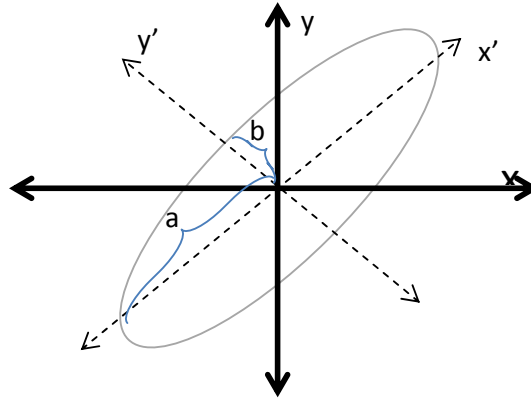


Figure 2 Ellipse with major axis =2a and minor axis =2b

Spatial moments are often used to describe the shape of a region. There are three second order spatial moments of a region. They are denoted by μ_{rr} , μ_{rc} , and μ_{cc} and are defined as follows:

Second-order row moment:

$$\mu_{rr} = \frac{1}{A} \sum_{(r,c) \in R} (r - \bar{r})^2 \quad (6)$$

Second-order mixed moment:

$$\mu_{rc} = \frac{1}{A} \sum_{(r,c) \in R} (r - \bar{r})(c - \bar{c}) \quad (7)$$

Second-order Column moment:

$$\mu_{cc} = \frac{1}{A} \sum_{(r,c) \in R} (c - \bar{c})^2 \quad (8)$$

Thus μ_{rr} measures row variation from the row mean, μ_{cc} measures column variation from the column mean, and μ_{rc} measures row and column variation from the centroid.

To determine the lengths of the major and minor axes following equation are used

$$\text{Major axis length} = 2\sqrt{2} \sqrt{\mu_{cc} + \mu_{rr} + \sqrt{(\mu_{cc} - \mu_{rr})^2 + 4\mu_{rc}^2}} \quad (9)$$

$$\text{Minor axis length} = 2\sqrt{2} \sqrt{\mu_{cc} + \mu_{rr} - \sqrt{(\mu_{cc} - \mu_{rr})^2 + 4\mu_{rc}^2}} \quad (10)$$

IV. References

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