# Color Image Edge Detection Based on Cube Similarity

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***Abstract*—The algorithm of color image edge detection was studied. An edge detection algorithm based on cube similarity was put forward, and there were some related problem to be introduced, for example: the concept of color space, classification and so on. The algorithm, to a certain extent, reasonably structures the correlation of R, G, B three color components, and which makes the relevant color vector to quantization problems, to the development of more perfect, people are more familiar with the field. Through the experiment, the algorithm can be fully by the color of the image information, make the original color image edge get more complete.**

***Keywords-Color Image, Edge Detection, Cube Similarity, RGB Color Space***

## I. INTRODUCTION

For computer analysis and image recognition, image edge information is very important and reflects the local features in the image of some discontinuity, such as color mutation, gray mutation, etc. Image edge means the beginning of a region in the image and the end of another area[1]. In image recognition, can be based on edge extracted image features, it contains a wealth of internal information, for example shape, step nature and direction and so on. In addition, the observer can outline the target object through the edge[2].

At present, People have a lot of research on gray image edge detection, with some relatively mature detection algorithm, such as Robert gradient operator, Sobel operator, Canny operator and the Laplace operator, etc. Compared with the gray image, however, there are more color information included in the color image, 90% of the edge is the same, there are 10% of the edge is undetectable, this suggests that more suitable for the human eye from the image background and target recognition is not the brightness but the chromatism[3]. Color image edge detection, therefore, more and more be taken seriously, people have put forward some relevant algorithms, such as extended classical operator based on color space, based on mathematical morphology algorithm, etc., but the effect is not very ideal, and don't have universality.

This article in RGB color space to image edge detection, this paper proposes a edge detection algorithm based on cube similarity, The algorithm to detect the edges of the image into a test cube difference of change, and the algorithm to implement simple, the edges of image can be more clear be detected. Can be concluded from the result of the experiment, the algorithm can more accurately detect the image edge, has good continuity and practicability.

## II. COLOR SPACE

### A. The basic concept

We often use color space to indicate and produce color, it can be understood as using mathematical method to describe the color. For example, based on red, green and blue three colors of phosphor luminescence the color of expression, often used to display screen; Based on the green, magenta, yellow and black four colors of reflection and absorption the color of definition, often used in color printing; Based on the hue, saturation and brightness of color, more accord with human visual perception.

Although, different color space can be used in different occasions, but because of the color information in the space can be broken down into three basic characteristics, so commonly used 3d model to represent the color space. In this model, each point has one to one correspondence with color. It also shows that each color corresponds to a point in the model, on the contrary, each point in the model represents a color[4].

### B. The classification of color space

From the perspective of different classification, the classification of color space is also different. Technically, color space can be divided into the following three types [5]:

(1) RGB color space. This color space applies in the television and on the monitor color display system widely. Such as RGB, HSV, HSL, and HIS color spaces. In printing technology and display technology, the color space is often called the color model. On the color normally used "color space" describes, and on the color combination is often use" color model "to describe.

(2) CIE and XYZ color space. International commission on illumination to define this kind of space, usually used as the basic method for measuring color, is the criterion for color space. In this kind of color space is widely used in scientific computing, it mainly uses device-independent color representation. This kind of color space can be used as two kinds of can't direct conversion of color space filtering.

(3) TV system and YUV color space. This type of color space, compress the chrominance information, thereby effectively quickly broadcast TV color images.

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From the human eye perception of color, the color space and can be divided into the following three types [5]:

(1) hybrid color space. Namely, according to certain proportion the three primary colors through some channel synthetic colors. For example, XYZ, CMY and RGB color space.

(2) nonlinear chroma and brightness of color space. For color perception is to use two independent components, for the perception of color is to use the rest of a component. For black and white images, just use a component can be completely expressed out.

(3) hue, intensity, and saturation color space. For color perception using hue and saturation is described, can eliminate the impact on the brightness of more effective, and color can be more intuitive explanation.

From the perspective of component contribution, color space can be divided into the following three types [5]:

(1) adding type .

(2) subtraction type .

(3) hybrid .

## III. EDGE DETECTION BASED ON CUBE SIMILARITY

### A. *Select the color space*

RGB (Red, Green, Blue) color space is one of three basic colors, red, green and blue are added to produce a variety of colors, the most common color space [6]. In digital image processing, it is the most commonly used, such as representation of BMP true color image is stored separately red, green, blue three color components [7]. Because the RGB color space of the device independence, it is widely used in color TV and on the screen. In RGB space, according to the theory of three primary colors, any saturation of shade and hue can by adjusting the R, G, B three basic colors and their respective strength ratio [8] :

$$F = r[R] + g[G] + b[B] \tag{1}$$

Among them, F is used to represent a certain color, = means to match, [R], [G], [B] respectively three primary colors, r, g, b three colors in their respective strength ratio coefficient, and meet the conditions: r + g + b = 1 [8].

In RGB color space, can directly through the edge detection to obtain a basically meet the edge information of optimal effect [9], so we selected the RGB space directly, so that can minus the image color space conversion process, to avoid the conversion in the image of certain information in error or lost, at the same time, also reduced the amount of calculation, improve the accuracy.

### B. *Edge detection principle*

For the human eye, can with the color changes, to identify the edge of the image. However, for a computer, the color change is very abstract, so will not like the human eye is easy to identify the different colors of edge. In this paper, each pixel of the image constitutes a cube , the three color components of the pixel R , G, B respectively cube posed long , width and height . If the pixel color change, so the structure of the cube shape will change too, namely, to establish the cube shape and color. Thus by comparing the shape of a cube to identify the edge of the image, turn abstract concepts to a quantifiable concept.

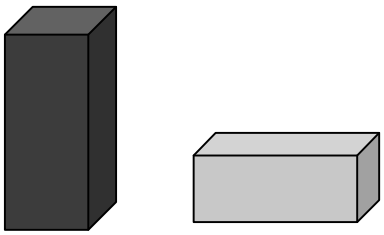
As shown in figure 1, among them, the cube A length, width and height of 60, 60, 60, respectively, then constitute the cube pixels R = 60, G = 60, B = 60; Cube B the length, width and height of 200, 200, 200 respectively, then constitute the cube pixels R = 200, G = 200, B = 200. As you can see, if the shape of a cube has changed, with the color will change, but the root cause of the color change is the value of R, G, B in change, and this is the essence of the cube shape change.

For the R, G, B three components constitute the cube, generally has the following three conditions:

(1) the adjacent pixels, constitute the volume of a cube is very different;

(2) the volume difference is small, but the shape of cube is a big difference;

(3)the volume difference is small, the cube shape difference is lesser also.



(a) the cube A (b) the cube B

Figure 1. Cube change between shape and color

First, volume difference is very big, is due to the cube of length, width and height, one or more large difference, namely color space three component R, G, B value difference is big, also is the color of the pixel difference is bigger, the image is likely to exist in the edge.

Second, the volume difference is smaller, the cube shape difference is small, indicating a cube of length, width, high value difference is very big, same as above described, there are likely to be the edge image.

The third, the volume difference is smaller, the cube shape difference is small, can be thought of as similar value R, G, B three components, namely the adjacent pixels belongs to the same area, there is no edge.

Thus, you can through the above three kinds of judging color difference between the two pixels, to detect the image edge.

### C. *Edge detection steps*

In 1970, Sobel presents a classical edge detection operator, the operator is based on first derivative , was later referred to as "Sobel operator". Because the operator has quick computing speed, detecting the edge of a continuous and smooth, so widely used in many areas [10]. Sobel operator according to the principle of gray level peaked at edge points, the use of pixels of up, down, left, right four

neighborhood gray weighted algorithm for edge detection [11]. In this article, in order to improve the precision of the algorithm, the improved Sobel operator, inspired by the method in kirsch operator, to expand the template Sobel operator to eight directions, so that they can more effectively extracted from multiple directions, as well as more complete access to the edge. The template is as follows:

$$\begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix}, \begin{bmatrix} -2 & -1 & 0 \\ -1 & 0 & 1 \\ 0 & 1 & 2 \end{bmatrix}, \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix}, \begin{bmatrix} 0 & 1 & 2 \\ -1 & 0 & 1 \\ -2 & -1 & 0 \end{bmatrix}$$

$$\begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix}, \begin{bmatrix} 2 & 1 & 0 \\ 1 & 0 & -1 \\ 0 & -1 & -2 \end{bmatrix}, \begin{bmatrix} 1 & 0 & -1 \\ 2 & 0 & -2 \\ 2 & 0 & -1 \end{bmatrix}, \begin{bmatrix} 0 & -1 & -2 \\ 1 & 0 & -1 \\ 2 & 1 & 0 \end{bmatrix}$$

Based on the previous detection principle, the specific steps are as follows:

(1)traverse all pixels in the original color image, extraction of each pixel of the three color component R, G, B, and obtain the corresponding to the three color component is the length, width and height of the cuboid.

(2)According to the volume of the cuboid calculation formula, the length, width and height of the cuboid, can calculate the volume V, again by the above eight Sobel operator calculates the gradient volume V1 to V8.

Take the first operator as the example, a pixel(i,j) in a color image the definition formula of gradient volume V1 (i, j) :

$$v_1 = v(v(i-1, j+1) + 2 \times v(i, j+1) + v(i-1, j+1) - v(i-1, j-1) - 2 \times v(i, j-1) - v(i-1, j-1)) \quad (2)$$

Among them,

$$v(i-1, j+1) = R(i-1, j+1) \times G(i-1, j+1) \times B(i-1, j+1) \quad (3)$$

Similarly, the definition formula of gradient volume V2 to V8:

$$v_2 = v(v(i, j+1) + 2 \times v(i+1, j+1) - v(i-1, j) - 2 \times v(i-1, j-1) - 2 \times v(i-1, j-1) - v(i, j-1)) \quad (4)$$

$$v_3 = v(v(i+1, j+1) - 2 \times v(i-1, j+1) - 2 \times v(i-1, j) + 2 \times v(i+1, j) - v(i-1, j-1) + v(i+1, j-1)) \quad (5)$$

$$v_4 = v(v(i, j-1) + 2 \times v(i+1, j-1) - v(i-1, j) - 2 \times v(i-1, j+1) + v(i+1, j) - v(i, j+1)) \quad (6)$$

$$v_5 = v(v(i-1, j-1) + 2 \times v(i, j-1) - v(i+1, j-1) - v(i-1, j+1) - 2 \times v(i, j+1) - v(i+1, j+1)) \quad (7)$$

$$v_6 = v(2 \times v(i-1, j-1) + v(i, j-1) + v(i-1, j) - v(i, j+1) - v(i+1, j) - 2 \times v(i+1, j+1)) \quad (8)$$

$$v_7 = v(v(i-1, j-1) - v(i+1, j-1) + 2 \times v(i-1, j) - 2 \times v(i+1, j) + 2 \times v(i-1, j+1) - v(i+1, j+1)) \quad (9)$$

$$v_8 = v(2 \times v(i-1, j+1) + v(i, j+1) - 2 \times v(i+1, j-1) + v(i-1, j) - v(i+1, j) - v(i, j-1)) \quad (10)$$

(3) If the V1 to V8, one of which is greater than the threshold (the threshold is averaging k times ), then that (i,j) is an edge point.

(4)If the two pixels with the same volume , you need to compare the R, G, B three components , and if there is a component of the disparity , it is also considered as an edge point .

Among them, according to the different image adjust the value of K, in the image, if the edge is more complex, want to choose relatively low threshold, so the value of K is smaller, on the contrary, in the image, if the edge is scarce, to choose a relatively high threshold, so the value of K is larger.

### *D. refine edge*

As a result of the above methods to get the edge sketchy , Prewitt operator thinning method is adopted in this paper, for detecting result has carried on the elaboration, such not only can highlight the characteristics of shape and can reduce the redundant information [12].

## IV. THE EXPERIMENTAL RESULTS

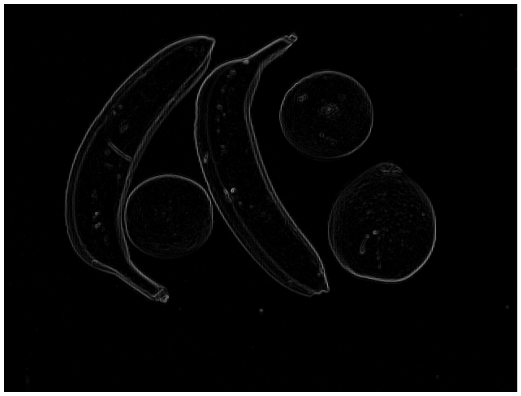
In figure 2 (b), (c), (d) is respectively by the method of this article, Prewitt operator and Sobel operator, the result of a color image(figure 2 (a)) edge detection. Results can be obtained from the experiment, in this paper, the algorithm make full use of the color characteristics of the image, compared with the traditional edge detection operator, make the outline of the original color image information is more complete, leading to more effective to detect the image edge [13].

## V. CONCLUSION

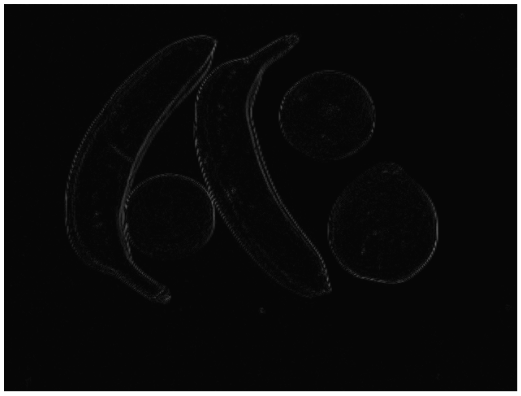
To sum up, This paper presents an algorithm based on similarity cube, actually the first use of R, G, B three color components in the demarcation of edge from other pixels in the image, and then through the proposed an improved eight direction Sobel operator for further testing, the advantage is that make the testing results of the more complete, and, with

this algorithm in the process of detection can make abstract problems embodied, so as to have efficient practicality.
On the basis of studying the algorithm in this paper, still need to be further in-depth study is under the condition of the same volume, how to distinguish between the pixel color component.

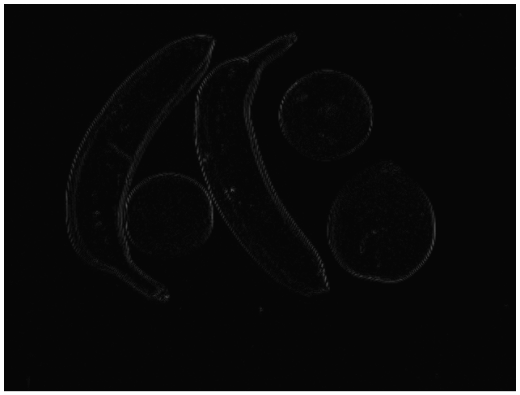
(a) The original image



(b) the paper method



(c) Prewitt method



(d) Sobel method

Figure 2. the experimental results

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