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A Color YUV Image Edge Detection Method Based on Histogram Equalization Transformation

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Abstract: **Because Color is a powerful descriptor of the color image, so color edge detection has been a staple of color image segmentation. The paper analyzed the methods of RGB image edge detection, the color image edge detection method is improved according to the two principles that are conversion transformation between RGB color space and YUV color space and histogram equalization transformation. The four steps of the detailed YUV image edge detection method are as follows: decomposing the YUV image, processing the Y component, composing the Y,U and V component and YUV-to-RGB conversion transformation. The experiment results show that the improved method compared with the RGB image edge detection methods can not only raise the effect of color image, but also simplify the method of color image edge detection.**

Keywords: Histogram Equalization; Color Image; YUV Color Space; Edge Detection

I. . INTRODUCTION

Edge detection is the important precondition of image segmentation, the researchers have proposed a series of gray color edge detection methods and have obtained the very good effect. Color is a powerful descriptor and it plays the important role in the aspect of digital image denotation. The statistic shows that about 90% edge information in the color image is the same as in the gray image, that is to say, about 10% edge information in the color image has not been detected, so it is essential that to research the problem of color image edge detection[1,2,3,4].So during the last years the researchers have put forward a lot of arithmetic on RGB image edge detection. Its material steps are the three steps are as follows: expanding the edge detection method to the three components of RGB color space, combining the edge of the three components by definite logic algorithm and obtaining the color image edge. The common shortcomings of the RGB image edge detection arithmetic are the low speed and the color losses after the each component processing[4,5].So YUV color space that is more according with the color vision characteristic than the other color space can be adopted during the processing of the color image edge detection, the paper proposes the basic steps of YUV image edge detection method and improves it according to histogram equalization.

II. RGB AND YUV COLOR SPACE

A. Difference Between RGB and YUV Color Space

RGB and YUV color space are two classes according with the color vision characteristic[3].

RGB color space is a kind of mixture color space that is composed by primary colors red(R), green(G) and blue(B) . The main characteristic is that the distance between the two color points is not equal with the difference of vision characteristic and can not obtain the hue, saturation and brightness attribute through the RGB data.

YUV color space is a kind of nonlinear luma/chroma one in which the Y component shows the luma apperception and the two independent component U and V show the chroma apperception. The main characteristic is that every component is independent each other.

B. Conversion Between RGB and YUV Color Space

The color difference U and V in YUV color space are given by the equations:

$$U = 0.493(B - Y)$$

$$V = 0.877(R - Y)$$

so the conversion between RGB and YUV color space is given by the equations:

$$\begin{bmatrix} Y \\ U \\ V \end{bmatrix} = \begin{bmatrix} 0.299 & 0.587 & 0.114 \\ -0.147 & -0.289 & 0.436 \\ 0.615 & -0.515 & -0.100 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 1 & 0.000 & 1.1400 \\ 1 & -0.369 & -0.581 \\ 1 & 2.029 & 0.000 \end{bmatrix} \begin{bmatrix} Y \\ U \\ V \end{bmatrix}$$

III. ANALYSIS OF RGB COLOR IMGE EDGE DETECTION METHODS

A. Directional Operator Method

The directional operator method is one of RGB image edge detection methods[6,7]. There are many cases in which processes based on individual color planes are not equivalent to

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working directly in RGB vector space. It will be demonstrated that vector processing is illustrated by color edge detection and color image region segmentation.

Define the vector $\mathbf{u}$ and $\mathbf{v}$ as the unit vector $\mathbf{r}$, $\mathbf{g}$ and $\mathbf{b}$ of RGB color space:

$$\mathbf{u}=\frac{\partial R}{\partial x}\mathbf{r}+\frac{\partial R}{\partial x}\mathbf{g}+\frac{\partial R}{\partial x}\mathbf{b}$$
$$\mathbf{v}=\frac{\partial R}{\partial y}\mathbf{r}+\frac{\partial R}{\partial y}\mathbf{g}+\frac{\partial R}{\partial y}\mathbf{b}$$

Define the scalar g_{xx}, g_{xy} and g_{yy} as the vector product of the vector $\mathbf{u}$ and $\mathbf{v}$:

$$g_{xx}=\mathbf{u}\cdot\mathbf{u}=\left|\frac{\partial R}{\partial x}\right|^2+\left|\frac{\partial G}{\partial x}\right|^2+\left|\frac{\partial B}{\partial x}\right|^2$$
$$g_{xy}=\mathbf{u}\cdot\mathbf{v}=\frac{\partial R}{\partial x}\frac{\partial R}{\partial y}+\frac{\partial G}{\partial x}\frac{\partial G}{\partial y}+\frac{\partial B}{\partial x}\frac{\partial B}{\partial y}$$
$$g_{yy}=\mathbf{v}\cdot\mathbf{v}=\left|\frac{\partial R}{\partial y}\right|^2+\left|\frac{\partial G}{\partial y}\right|^2+\left|\frac{\partial B}{\partial y}\right|^2$$

Direction of maximum rate of change of $c(x,y)$ as a function (x,y) is given by angle:

$$\theta(x,y)=\frac{1}{2}\arctan\left[\frac{2g_{xy}}{(g_{xx}-g_{yy})}\right]$$

and that the value of the rate of change (i.e.,the magnitude of the gradient) in the directions given by the elements of $\theta(x,y)$ is given by:

$$F_\theta(x,y)=\left\{\frac{1}{2}[(g_{xx}+g_{yy})+(g_{xx}-g_{yy})\cos 2\theta+2g_{xy}\sin 2\theta]\right\}^{1/2}$$

B. Component Gradient Operator

The material of component gradient operator is to process the decomposed components of the RGB color image[5,8].

The main idea of the component gradient operator method is that the R,G, and B component given by an RGB color image.

The basic component gradient operator of color image edge detection method in RGB color space consists of three steps. At first, the R, G and B component is given by an RGB color image. Secondly, the component edge is detected by applying gray image gradient operator. And finally the result image is given by the processed R, G and B component.

It involves the following steps:

Step 1: The R, G and B component is computed.

Step 2: The component is separately processed using the way of the gradient operator.

Step 3: The RGB color image is given through the processed separate components.

Let p be an arbitrary vector in RGB color space:

$$p=\begin{bmatrix}p_R\\p_G\\p_B\end{bmatrix}=\begin{bmatrix}R\\G\\B\end{bmatrix}$$

This equation indicates that the components of p are simply the RGB components of a color image at a point. We take into account the fact that the color components are a function of coordinates (x,y) by using the notion:

$$p(x,y)=\begin{bmatrix}p_R(x,y)\\p_G(x,y)\\p_B(x,y)\end{bmatrix}=\begin{bmatrix}R(x,y)\\G(x,y)\\B(x,y)\end{bmatrix}$$

The sobel gradient operator of the R, G and B component is given by the equations:

$$\begin{aligned}G_x{}^P&=((P(x-1,y-1)+2P(x-1,y)+P(x-1,y+1))\\&\quad-(P(x+1,y-1)+2P(x+1,y)+P(x+1,y+1))\\G_y{}^P&=((P(x-1,y-1)+2P(x,y-1)+P(x+1,y-1))\\&\quad-(P(x-1,y+1)+2P(x,y+1)+P(x+1,y+1))\end{aligned}$$

The laplace gradient operator of the R, G and B component is given by the equations:

$$\nabla^2[f(x,y)]=\begin{pmatrix}\nabla^2R(x,y)\\\nabla^2G(x,y)\\\nabla^2B(x,y)\end{pmatrix}$$

$$\begin{aligned}\nabla^2P(x,y)&=[P(x+1,y)+P(x-1,y)+P(x,y+1)+P(x,y-1)]\\&\quad-4P(x,y)\\P(x,y)&=P(x,y)-\nabla^2P(x,y)\\&=P(x,y)-\{[P(x+1,y)+P(x-1,y)+P(x,y+1)\\&\quad+P(x,y-1))]-4P(x,y)\}\\&=5P(x,y)-[P(x+1,y)+P(x-1,y)+P(x,y+1)\\&\quad+P(x,y-1)]\end{aligned}$$

If the diagonal element is added, then $\nabla^2Y(x,y)$ is given by the equations:

$$\begin{aligned}\nabla^2P(x,y)&=[P(x+1,y-1)+P(x+1,y+1)+P(x-1,y+1)\\&\quad+P(x-1,y-1)+P(x+1,y)+P(x-1,y)\\&\quad+P(x,y+1)+P(x,y-1)]-8P(x,y)\end{aligned}$$

where $P=R,G,B$

IV. STUDY OF YUV COLOR IMAGE EDGE DETECTION METHOD

A. Steps of Proposed Method

The basic idea of the YUV color image edge detection process is to only process the Y component. The basic color image edge detection method in YUV color space consists of four steps. At first, color space is converted from RGB to YUV. Secondly, the Y, U and V component is computed by the YUV color image. In the third step, the Y component is only processed including the histogram equalization. And finally the YUV color image is given through the processed separate components.

It involves the following steps:

Step 1: The YUV image of the given RGB image is obtained by conversion of color space.An RGB color image

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are decomposed in turn the three components that are the Y component, the U component and the V component.

Step 2: The U and V components are kept unchanged .The Y component is processed by the gradient operator.

Step 3: The processed Y component is histogram equalization transformed.

Step 4: The separate component images are reconstructed the RGB color image.

B. Gradient Operator

The sobel gradient operator of the Y component is given by the equations:

$$\begin{aligned} G_x^Y &= ((Y(x-1,y-1)+2Y(x-1,y)+Y(x-1,y+1)) \\ &\quad -(Y(x+1,y-1)+2Y(x+1,y)+Y(x+1,y+1)) \\ G_y^Y &= ((Y(x-1,y-1)+2Y(x,y-1)+Y(x+1,y-1)) \\ &\quad -(Y(x-1,y+1)+2Y(x,y+1)+Y(x+1,y+1)) \end{aligned}$$

The laplace gradient operator of the Y component is given by the equations:

$$\begin{aligned} \nabla^2 Y(x,y) &= [Y(x+1,y)+Y(x-1,y)+Y(x,y+1)+Y(x,y-1)] \\ &\quad -4Y(x,y) \end{aligned}$$

$$\begin{aligned} g(x,y) &= f(x,y)-\nabla^2 f(x,y) \\ &= f(x,y)-\{[f(x+1,y)+f(x-1,y)+f(x,y+1) \\ &\quad +f(x,y-1))]-4f(x,y)\} \\ &= 5f(x,y)-[f(x+1,y)+f(x-1,y)+f(x,y+1) \\ &\quad +f(x,y-1)] \end{aligned}$$

If the diagonal element is added, then $\nabla^2 Y(x,y)$ is given by the equations:

$$\begin{aligned} \nabla^2 Y(x,y) &= [Y(x+1,y-1)+Y(x+1,y+1)+Y(x-1,y+1) \\ &\quad +Y(x-1,y-1)+Y(x+1,y)+Y(x-1,y) \\ &\quad +Y(x,y+1)+Y(x,y-1)]-8Y(x,y) \end{aligned}$$

V. RESULTS AND COMPARISIONS

The proposed algorithm have experimented and researched on color images under the circumstance MATLAB7.0. In the experiment, one color image (jpg format ,1024×727×24) was used as base image, shown in Figure 1. The results of the experiment are shown in Figure 2，3，4，5，and 6.

Figure 1. The Original Color Image

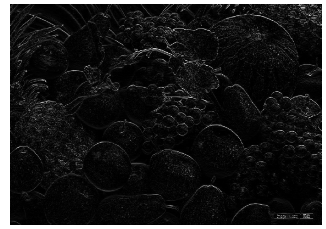

Figure 2. Result of Directional Operator Way

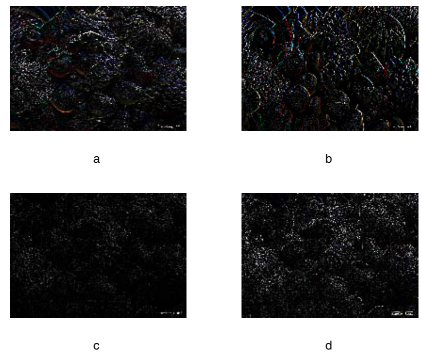

Figure 3. Result of R,G, and B Component Way

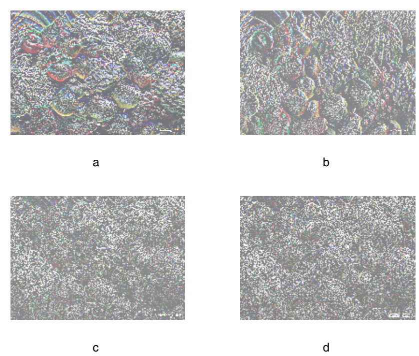

Figure 4. Result of R,G, and B Component Way and Histogram Equalization

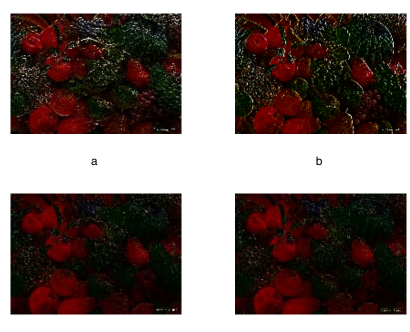

Figure 5. Result of Y Component Edge Detection

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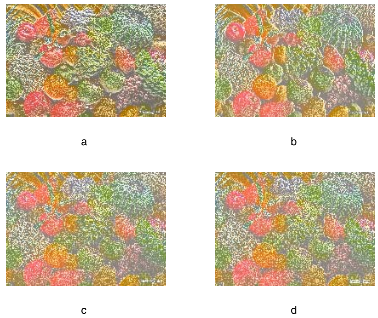

Figure 6. Result of Y Component Edge Detection and Histogram Equalization

Figure1 is the original image with the edge of various directions.Figure2 is the edge image by directional operator way.Figure3 is the edge images by processing R,G, and B component by decomposing RGB image. Where Figure3(a) is obtained by the horizontal sobel operator, Figure3(b) is obtained by the vertical sobel operator, Figure3(c) is obtained by the laplace operator, and Figure3(d) is obtained by the laplace operator with angle element. Figure4 is similar to Figure3.Figure5 is the edge images by processing Y component through decomposing the YUV image. Where Figure5(a) is obtained by the horizontal sobel operator, Figure5(b) is obtained by the vertical sobel operator, Figure5(c) is obtained by the laplace operator, and Figure5(d) is obtained by the laplace operator with angle element. Figure6 is similar to Figure5.

The figure 6 is the edge detection effect of the proposed algorithm in this paper. From the above figure, we can see that the detected edges are more exact based on the new algorithm, and the color edges also are detected effectively.

VI. CONCLUSION

The color image edge detection process based on YUV color space is given in the paper. The experiment results indicate that the proposed method is not only a simple, practical algorithm, but also a effective edge detection algorithm. As color edge detection is different from gray edge detection, the method need be applied on a large database of color images. To using more color space also will be the other way of color edge detection.

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