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距離情報に基づく画像コントラスト強調

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あらまし 画像強調、特にカラー画像強調は画像処理研究の一つの重要な分野である。画像コントラスト強調は画像の品質を高めるようにカラー画像のコントラストを高めることである。カラー画像にとって、距離感は真実感を表現する重要な要素である。そのため、筆者らはヒストグラム平坦化を改良し「加重ヒストグラム平坦化」を提案した。画素の距離情報を利用し計算した重みをヒストグラムの計算と平坦化の輝度変換に使用する。近い画素の領域に強めにコントラスト強調し、遠い領域に弱めに強調することによって画像の距離感を強調できる。カラー画像に本提案手法の施す実験を行い、提案手法の有効性の見通しを得た。

キーワード 画像処理、画像コントラスト強調、距離情報、ヒストグラム平坦化

Image Contrast Enhancement Based on Distance Information

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Abstract Image enhancement, especially color image enhancement is a critical area in image processing research. Image contrast enhancement is a Image contrast enhancement is to enhance the contrast of color image so as to make the image more vivid and beautiful. Distance sense is a critical element to present the reality of color images. In order to improve the distance sense, we optimize the histogram equalization (HE) with distance information in enhancement processing and propose a Weighted Histogram Equalization (WHE) method. Near areas of the images are enhanced strongly and far areas weakly. Experimental results show that the proposed method is effective.

Keyword Image Processing, Image Contrast Enhancement, Distance Information, Histogram Equalization

1. Introduction

Image enhancement, especially color image enhancement is a critical area in image processing research. Contrast enhancement increases the total contrast of an image by making light colors lighter and dark colors darker at the same time, so that the quality of an image is improved for visual perception of human beings.

Some color enhancement methods were proposed. Histogram Equalization (HE) is a well-known image processing algorithm, which possibly converts the input images into contrast-enhanced images. Based on HE Buzuloiu et al. [1] proposed an adaptive neighborhood histogram equalization method, and Trahanias et al.[2] proposed a three Dimension histogram equalization method in RGB cube. Thomas et al. [3] proposed an enhancement method by considering the correlation between the luminance and saturation components of the image locally. A method for enhancing the color contrast in xy-chromaticity diagram was proposed by Lucchese et al. [5]. Shyu et al. [6] suggested a genetic algorithm approach in which the enhancement problem is formulated as an optimization problem. In recent years, multi-scale technologies have been

widely used in image processing. For example, Toet [7] proposed a schema by representing the original luminance and saturation components of a color image at multiple spatial scales. Lu [8] proposed a contrast enhancement method based on multi-scale gradient transformation. Brown [9] proposed an adaptive strategy for wavelet based image enhancement.

The related research mentioned above is useful for color image enhancement. However, 3D sense is not so much considered. Many 3D display systems using reticular lens screen etc. have been developed. However, 3D sense cannot always be sufficiently presented. If the texture of the displayed 3D object is reasonably enhanced, the sense of 3D might be enhanced also. However, not many works on the 3D contrast enhancement can be seen. In this paper, we propose contrast enhancement method, which focuses on improving the distance sense of the images. We optimize the HE with distance information in enhancement processing and propose a Weighted Histogram Equalization (WHE) method.

This paper is organized as follows. In Section 2, the basic idea of our method is described. Section 3 elaborates on our proposed method. Experimental results are shown in Section 4. Section 5 concludes this paper.

2. BASIC IDEA

2.1. Distance Information

Distance is an important element of 3D sense in virtual reality. According to the feature of human vision, near areas from the viewpoint tend to be visible clearly while far areas tend to be visible not clearly. Our method is to enhance the contrast of near areas and suppress that of far areas so as to increase distance sense of the image.

Original HE is to transform the gray levels so that the histogram of the resulting image is equalized to be a constant. Our proposed method calculates a weighted histogram instead of the common histogram. Pixels in "near area" (the distance from view point is small) are given large weight and those in "far area" (the distance is large) are given small weight when calculating the histogram. Compared with HE, our proposed method is to give wider luminance range for near areas and narrower range for far areas and enhance the distance difference so as to increase the 3D sense of the image.

2.2. Color Space

Our method is applied on HSV color space.

The RGB color space, in which color is specified by the amount of Red, Green and Blue present in the color, is known as the most popular color space. RGB is an additive and subtractive model, respectively, defining color in terms of the combination of primaries, whereas HSV color space encapsulates information about a color in terms that are more familiar to humans. In HSV color space, the color is decomposed into hue, saturation and luminance value, which is similar to the way humans, tend to perceive color. Ledley's research shows that the performance of HSV color space is good in color improving [3].

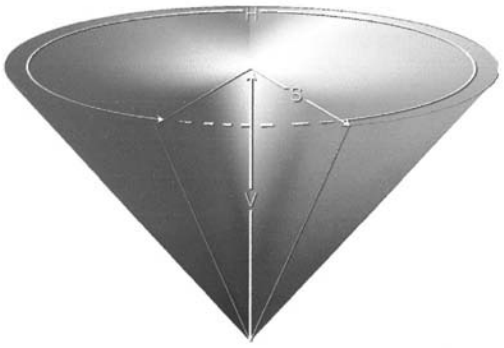

Fig.1 HSV Color Space

A color enhancement method should not convert, for example, a red color to a yellow color. Even if in some special cases such a conversion is needed, the color shifting should also be controlled. It is the hue component that indicates the color. Therefore, it is critical to consider hue in color enhancement method. Among the three components of HSV color space, hue is the attribute of a color, which decides which color it is. For the purpose of enhancing a color image, hue should not be changed for any pixel [4]. Compared with other perceptually uniform such as CIE LUV color space and CIE Lab color space, it is easier to control the Hue component of color and avoid color shifting in the HSV color space. Therefore, we chose HSV color space for our enhancement method.

In our method, we keep hue preserved and apply the enhancement method only to luminance.

3. ALGORITHM

3.1. Process Flow

Our proposed method consists of the following four steps:

1.convert RGB to HSV
2.distance-weight mapping
3.WHE
4.convert HSV to RGB

As mentioned before, WHE is applied on V component in HSV color space. Therefore, we must convert each pixel to HSV color space before processing. Then apply distance-weight mapping, weighted histogram computing. After that, convert

enhanced HSV value of each pixel back to RGB color space.

3.2. Distance-Weight Mapping

Distance-weight mapping is to convert distance information to certain weight. Distance information is saved in "distance image", a gray-level image with the same size as the original image. Distance of each pixel in the original image is presented by the luminance of pixel at the same position in the distance image. The larger the distance of a pixel is, the smaller its gray-level is.

In our method, we exploit linear mapping function Eq. (1).

$$W = \frac{D+255}{510} \qquad (1)$$

Here D is the distance described by the gray-level ($0 <= D <= 255$) and W is the weight in [0.5, 1].

3.3. WHE

WHE consists of the following process. Normalize V to an integer in [0, 255].

Let Nk be the total weight of pixels of $V = k$:

$$Nk = \sum_{p:\, Vp = k} Wp \qquad (2)$$

N being the total weight of pixels in the image:

$$N = \sum_{k=1}^{255} Nk \qquad (3)$$

For each input Vi ϵ [0, 255], compute straight output Vs (ϵ [0, 255]) with Eq.(4):

$$Vs = \frac{255}{N} \sum_{j=0}^{Vi} Nj \qquad (4)$$

Vo can be computed by Eq(5).

$$Vo = Va + (Vs - Va)* W \qquad (5)$$

Here Va is the average V of the image. Let M be the number of pixels in the image. Va can be computed with Eq.(6):

$$Vs = \frac{1}{M} \sum_{p} Vp \qquad (6)$$

Eq.(5) is used to distinguish the difference of distance. As we know, HE creates a mapping function and maps each input value to a fixed output result. If we use Vs in Eq.(4) as the final output, two pixels with same luminance value will convert to a same result whether they are far or near to the view point. To strongly increase the contrast of near area, we reduce the output range of "far areas". As shown in Figure 2, for the same input luminance of pixels, output range of far area is narrow and that of near area is wide.

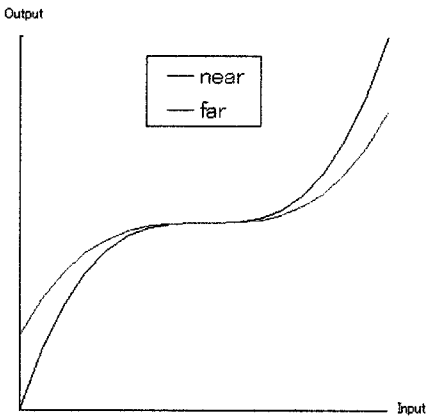

Fig.2 Output of Near Area and Far Area

From Eq.(1)—(6), we can compute output Vo for each input pixel with V component being Vi and weight being W.

4. EXPERIMENTAL RESULT

To test the performance of our proposed method, we apply the method to an image taken in 3D display system. Figure 3 shows the experimental result.

(a)

(b)

(c)

Fig.3 Experimental Result

. (a) is the original image, (b) is the result of HE on V component and (c) is the result obtained by our proposed method.

(b) increases the contrast of the original image but looks unnatural. (c) shows a more smooth and natural enhancement result.

The experimental result shows that our image enhancement method can successfully enhance the color image. Compared with HE, our WHE method made better performance.

5. CONCLUSION

This paper has proposed a contrast enhancement method based on distance information. Throughout WHE, near areas are strongly enhanced so as to present the difference caused by distance and improve 3D sense. It turns out that the proposed image enhancement method constitutes a successful enhancement of color images. However, there are still some remaining issues. The way to compute weight with distance information should be improved. Secondly, the relationship between luminance value and saturation is not considered in our enhancement method. Another topic is that sometimes the color contrast enhancement requires changing color and the hue component should also be adjusted. These issues are our next research topics.

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