An Improvement Method of Color Image Using Saturation Extension

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Abstract

In this paper, we propose a color image improvement method. The proposed algorithms are classified with the adaptive contrast stretching method for contrast enhancement and the adaptive saturation enhancement method for saturation enhancement. The adaptive contrast stretching method is to compensate a significant change of brightness while luminance is processed. The adaptive saturation enhancement method inhibits its saturation from de-saturation and over-saturation while chrominance is processed. The proposed algorithms are focused on a preference color processing in order to generate better image quality than the algorithms focused on a uniform color processing for human vision.

1. Introduction

Today, TV is a part of total info-communication that means not only the passive significance of the information retrieval but also the active one of the considering sensitive side. To improve the image quality, many researchers have investigated the contrast enhancement [1] and saturation enhancement [2-4].

The luminance processing enhances the contrast of the image but also leads to the color saturation change. Normally, increasing the luminance causes the decrease of color saturation. And it makes the blurred image. Decreasing the luminance leads to increase the color saturation. In some cases, it looks over-saturated. The over-saturated color is unnatural and uncomfortable. Therefore, the enhancement of chrominance is required for improving the quality of color image after the luminance enhancement.

In this paper, we describe a color image enhancement method that can be improved the image quality. We suggest the adaptive contrast stretching and saturation enhancement methods. These are the color improvement methods for preventing the over-saturation and de-saturation.

The paper is organized as follows: In section 2, the proposed method is discussed. Section 3 and 4 provide experimental results and conclusions respectively.

2. Proposed Method

In this paper, we propose the enhancement method of color image. The method processes in the luminance and the chrominance. If the image is the RGB color space, it would be too hard to apply the proposed method.

Hence we use YCbCr color space. To apply to YCbCr color space, we convert the RGB color space to YCbCr color space. The RGB color space transforms to the YCbCr colors using equation (1). On the other hand, YCbCr color space becomes the RGB one using equation (2). Y is the luminance, Cb is the difference of luminance and blue, Cr is the difference of luminance and red.

$$\begin{bmatrix} Y \\ Cb \\ Cr \end{bmatrix} = \begin{bmatrix} 16 \\ 128 \\ 128 \end{bmatrix} + \begin{bmatrix} 0.257 & 0.504 & 0.098 \\ -0.148 & -0.291 & 0.439 \\ 0.439 & -0.368 & -0.071 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} \quad (1)$$

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 1.164 & 0 & 1.596 \\ 1.164 & -0.392 & -0.813 \\ 1.164 & 2.017 & 0 \end{bmatrix} \begin{bmatrix} Y-16 \\ Cb-128 \\ Cr-128 \end{bmatrix} \quad (2)$$

A. Adaptive Contrast Stretching Method

The adaptive contrast stretching method is to improve contrast of images according to the histogram. Its flow is shown by Figure 1. The first is to determine the upper threshold and the lower one in the input histogram LUT (Look-up Table). Figure 2 shows the input histogram LUT.

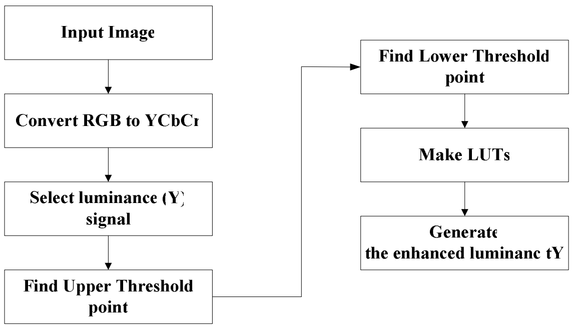


Fig. 1. The flow chart of adaptive contrast stretching

And then, we make the LUT for dynamic range stretching and contrast enhancement. To make the LUT, we define the new UT (Upper Threshold) and new LT (Lower Threshold) like Figure 2. The new UT is the point that is the two thirds of the largest value and original UT. The new LT is the point that is the one third of the lowest value and original LT.

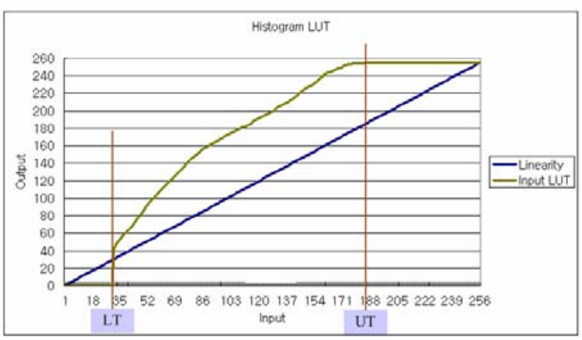


Fig. 2. Look-up table of input image

Finally, the histogram is stretched by the LUT according to the new upper threshold and the new lower one. The LUT is the summation of three linear equations which is represented by equation (3), one is from lowest value to new LT, another is from new LT to new UT and the other is from new UT to largest value. The enhanced luminance Y' makes the applying by LUT.

$$Y(x)=\begin{cases}\dfrac{LT'}{LT}x & ,x<LT\\ \dfrac{UT'-LT'}{UT-LT}x & ,LT\le x<UT\\ \dfrac{255-UT'}{255-UT}x & ,UT\le x\end{cases} \quad (3)$$

Where LT' is the new LT and UT' is the new UT. And x has the range from 0 to 255.

B. Adaptive Saturation Enhancement Method

The adaptive saturation enhancement method is to enhance the color image according to its color characteristics. Figure 3 shows the flow chart of this method.

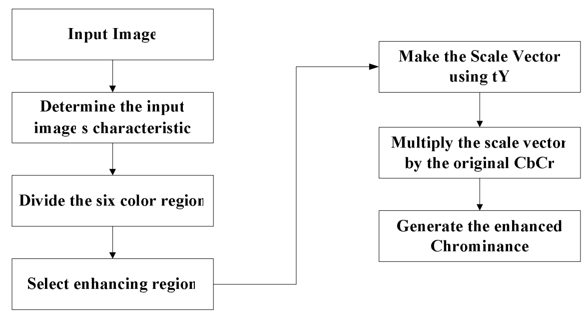


Fig. 3. The flow chart of adaptive saturation enhancement Method

Before the converting YCbCr, we find the characteristics of input color. It is from the average of R, G, B. For example, if the average of R is bigger than 128 which is the middle point in 8-bit processing, the image has the characteristic of Red. And then YCbCr color space divides the six color regions which consist of Red, Green, Blue, Magenta, Yellow and Cyan.

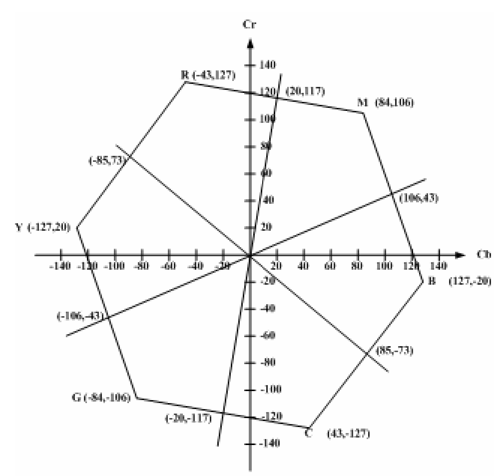


Fig. 4. Six color regions in CbCr domain

It extracts the equation between luminance and chrominance vector in each section to generate the saturation factor.

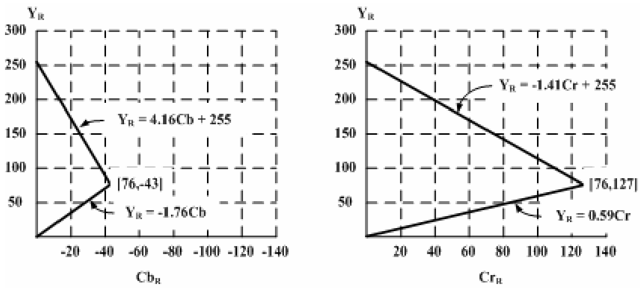


Fig. 5. Luminance (Y) and Chrominance (Cb,Cr) vector relationship in R section.

Figure 5 shows the two-dimensional YCbCr color model having the luminance level (Y) and the chrominance vector (CbCr). As shown in Figure 5, the valid area defines the two equations.

First, two equation of Cb in Red section are

$$Y_R = 4.16Cb_R + 255 \quad (4)$$

$$Y_R = -1.76Cb_R \quad (5)$$

And Cr is

$$Y_R = 0.59Cr_R \quad (6)$$

$$Y_R = -1.41Cr_R + 255 \quad (7)$$

Cb and Cr has another two equation based on the Y value 76 from Figure 5. In the case of Y <76, both line equation (5) and (6) are referenced, and the relationship of maximum chrominance vector corresponding to luminance Y as shown in equation (8).

$$[Cb_R \max, Cr_R \max] = \left[\frac{Y}{-1.76}, \frac{Y}{0.59}\right] \quad (8)$$

When the Y is greater than 76, the maximum chrominance vector is rectified by both line equations (4) and (7).

$$[Cb_R \max, Cr_R \max] = \left[\frac{Y-255}{4.16}, \frac{Y-255}{-1.41}\right] \quad (9)$$

Maximum chrominance equations evaluate in all section. And then we generate the adaptive saturation factor of an original image according to the maximum chrominance vector. The saturation factor as following,

$$\alpha = \min\left\{\left|\frac{Cb \max}{Cb}\right|, \left|\frac{Cr \max}{Cr}\right|\right\} \quad (9)$$

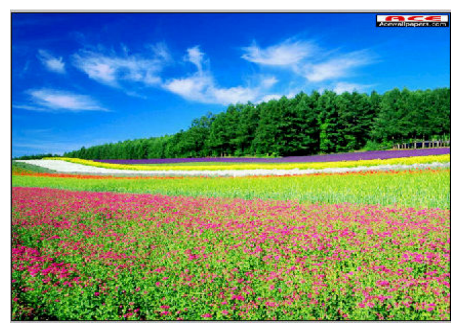
Finally we get the enhanced CbCr value that is multiplied the adaptive saturation factor by the original CbCr one. And it represented by:

$$[Cb', Cr'] = [\alpha \cdot Cb, \alpha \cdot Cr] \quad (10)$$

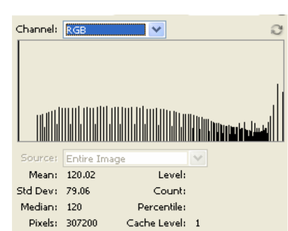
Where Cb'Cr' is the enhanced CbCr and CbCr is the original one.

3. Experimental Results

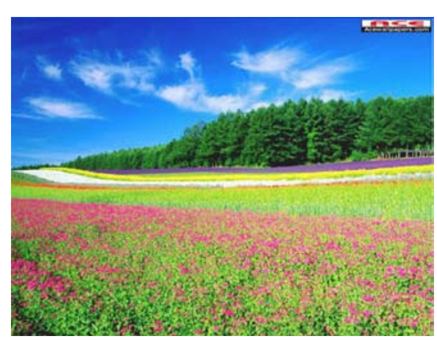
The performance of the proposed method is compared by the image quality between transformed images and original image. Figure 6 shows the image and the histogram of the original image, the histogram equalized image and the proposed image.



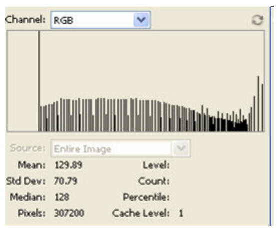
(a) Input Image



(b) The Histogram of Input Image

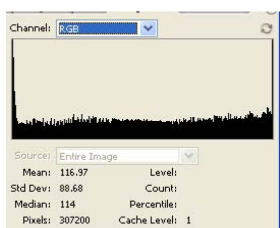


(c) Histogram Equalized Image



(d) The Histogram of Histogram Equalized Image

(e) Proposed Image



(f) The Histogram of Proposed Image
Fig. 6. Simulation Result

As shown in the Figure 6, the proposed image is the wider range in histogram than the histogram equalized image.

TABLE 1. Comparison of Simulation Results

	Input	Histogram Equalized	Proposed
Mean	120.02	129.89	116.97
Std. Dev.	79.06	70.79	88.68
Median	120	120	114

In the mean value, the low value signifies the darkness image. The mean value of histogram equalized image is the higher than the proposed one. It means the transient variation which is caused to the image distortion. Comparing the standard derivation of histogram equalized image and proposed image, the 88.68 of proposed image is more than the 70.79 of histogram equalized image. It means that the proposed image is distributed the whole histogram range. In addition to the green of proposed image's forest is the lighter than the histogram equalized image's. To enhance image gets the more vivid color. Like this, the proposed method protects the image distortion of much contrast changing and having uniformed enhancement without contour artifacts or over-saturation.

4. Conclusions

The proposed methods are to improve the quality of color image based on the human vision. It is suitable for the FPD (Flat Panel Display) that requires high-definition such as LCD monitor, LCD TV, PDP TV, and etc. The adaptive contrast stretching method is to allow higher level of brightness preservation and to avoid unpleasant artifacts and unnatural enhancement due to excessive equalization while enhancing the contrast of an input image. The adaptive saturation enhancement method is to prevent the color distortion of the over-saturation or de-saturation. Consequently the proposed method is effective in the improvement of the color image quality for the FPD.

5. Acknowledgements

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6. References

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