Image Enhancement Method by Saturation and Contrast Improvement

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Abstract

In this paper, an image enhancement method by saturation and contrast improvement is proposed. Histogram equalization with color difference makes higher contrast. By generating saturation amplification ratio with color difference, the saturation improves effectively. The experimental results show that the proposed algorithm has higher contrast and more natural – look than the conventional methods.

1. Introduction

Enhancing the contrast of images is one of the major issues in image processing. Contrast of an image is determined by its dynamic range, which is defined as the ratio between the brightest and the darkest pixel intensities[1]. Contrast enhancement techniques have various application fields for enhancing visual quality of low contrast images. Histogram Equalization (HE) is one of the well-known methods for enhancing the contrast of given images[5]. Histogram equalization makes a uniform distribution of the gray level for an input image[2]. Histogram equalization has been widely applied with conventional method. However, in consumer electronics such as Flat Panel Display (FPD), histogram equalization is rarely applied in directly, because significant change in brightness is occurred, and it makes unnatural-look image. Therefore, it is necessary to suppress the significant change of brightness[4]. In this paper, we propose an image enhancement method by saturation and contrast improvement to compensate color distortion that caused by the over enhancement.

This paper is organized as follows. In Sec.2, histogram equalization is described, and in Sec. 3, image enhancement method by saturation and contrast improvement is proposed. Experimental results and conclusions are given in Sec. 4, and 5, respectively.

2. Histogram Equalization

The histogram provides information for the contrast and overall intensity distribution of an image. The histogram of a digital image with gray levels in the range [0, L-1] is a frequency distribution function defined as

$$h(X_k) = n^k \tag{1}$$

For k = 0, 1, 2,…, L – 1, where X_k is the kth gray level of input, n^k is the number of the pixels in the image having gray level X_k.

$$P(X_k) = \frac{n_k}{n} \tag{2}$$

For k = 0, 1, 2,…, L – 1, where n is the total number of the pixels in the image. The $P(X_k)$ gives an estimate of the Probability Density Function (PDF). The technique for obtaining a uniform histogram is known as histogram equalization.

Based on the probability density function, the Cumulative Density Function (CDF) is defined as

$$CDF(X_k) = \sum_{j=0}^{k} P(X_j) = \sum_{j=0}^{k} \frac{n^j}{n} \tag{3}$$

where $CDF(X_{L-1}) = 1$ by definition. The histogram equalization defines the equation (3) as a transfer function, T(x), and a scheme that maps the input image into the entire dynamic range (X_0,.., X_{L-1}).

$$T(X) = x \times CDF(X_k) \quad (4)$$

The histogram equalization has an effect of stretching dynamic range, since histogram flattens the density distribution of the image.

3. Proposed algorithm

The major objective of the proposed algorithm is the enhancement of contrast and saturation. The proposed algorithm consists of contrast enhancement and saturation enhancement. The flow chart of the proposed algorithm is shown by Figure. 1.

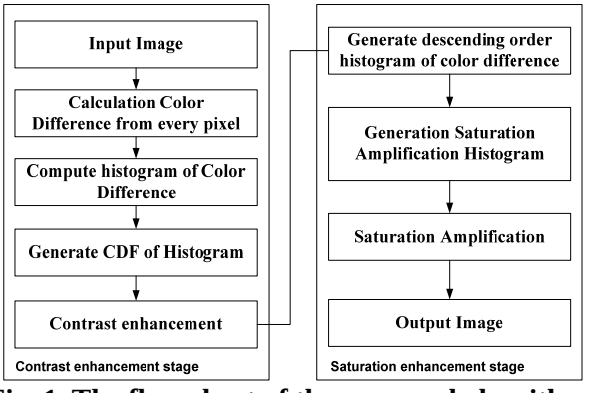


Fig. 1. The flow chart of the proposed algorithm

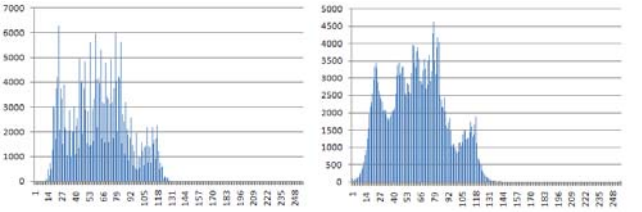
A. Contrast enhancement stage

The first step of in this stage, we calculate VCD (Value of Color Difference) defined as adding a center pixel and the absolute value of the difference between the center pixel and adjacent pixels.

$$VCD = I(x,y) + \frac{1}{8}\sum_{i=-1}^{1}\sum_{j=-1}^{1}|(I(x+i,y+j) - I(x,y)| \quad (5)$$

where I(x,y) represents a pixel value of an image, and i and j represent horizontal and vertical coordinates of a surrounded pixel in image respectively. After compute histogram of VCD in order to histogram equalization for contrast enhancement, generate the CDF (Cumulative Distribution Function) by using equation (3).

Histogram equalization is applied in the next step by using the CDF_{VCD} as a transfer function. Fig. 2(a) and 2(b) show the difference of general histogram and histogram with edge information.



(a) **(b)**

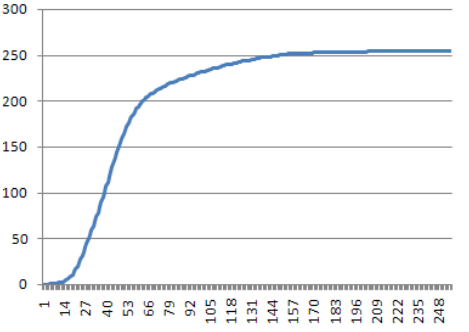
Fig. 2. General histogram and color difference included histogram

By applying the histogram equalization including the edge information for the low contrast image, it gives high contrast and suppresses the significant change in brightness.

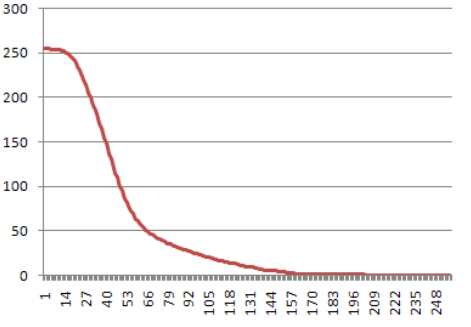
B. Saturation enhancement stage

In this stage, the main issue is the suppression of the color distortion that caused by contrast enhancement. Two CDF functions are required to determine the SAR (Saturation Amplification Ratio). One is the CDF of histogram of VCD that pre-computed in previous stage and shown in Fig. 3(a). The other is the D (Descending order)-CDF that represents the accumulation in the descending order, which is shown by Fig. 3(b).

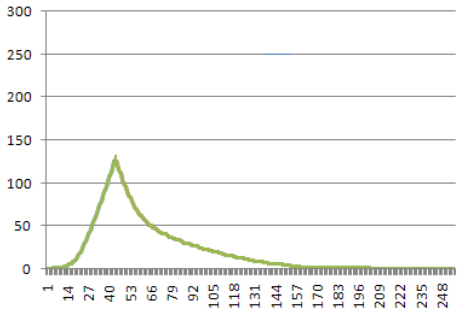
SAR is determined by selecting the minimum value of each CDF. SAR histogram is shown by Fig. 3(c). SAR should be normalized in order to make all values be in range between 1.0 ~ 1.5, which is shown by equation(6).



(a)



(b)



(c)

Fig. 3. Generation of the saturation amplification ratio

$$SAR[i] = 1 + \frac{Minimum\,Selected\,Value\,Histogram[i]}{Maximum\,Gray\,Level} \quad (6)$$

where i = 0,1,2,… 255, and enhanced saturation is obtained by multiplication of input saturation and SAR, i.e.,

$$Enhanced\ Saturation = Input\ Saturation[i] \times SAR[i] \quad (7)$$

By applying saturation multiplication in limited range, the saturation enhancement is applied in the range of no over-saturation. SAR and enhanced saturation is shown by Fig. 4.

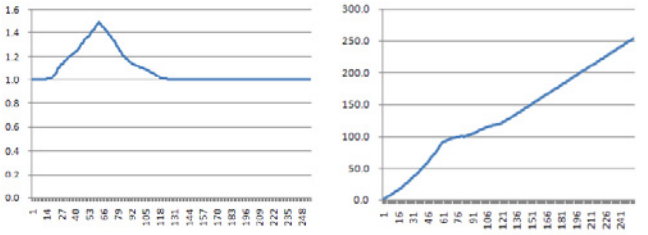
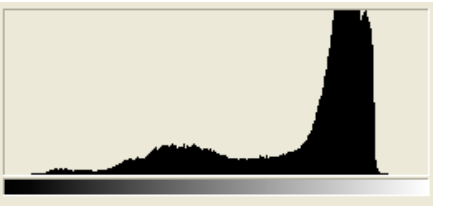


Fig. 4. SAR and Enhanced saturation

3. Experimental results

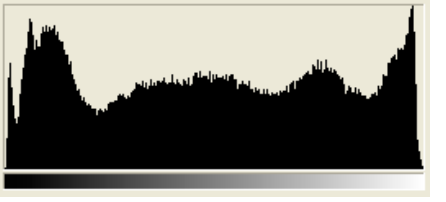
In this section, we present the experimental results of proposed algorithm compared with the conventional. The source image for experiment is *airplane* that has very low contrast because of concentrated pixel distribution to bright region (Fig. 4(a)). Fig 4(b) and fig. 4(c) are the results that based on the histogram equalization and proposed algorithm with their histogram. Each image of result has been enhanced in contrast. However, histogram equalization has the color distortion because histogram equalization does not preserve the naturalness of original color. Proposed algorithm preserves both brightness and naturalness of original color by contrast and saturation enhancement.

(a)-1



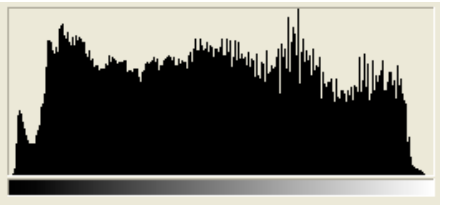
(a)-2

(b)-1



(b)-2

(c)-1



(c)-2

Fig. 4. Experimental results

4. Conclusion

In this paper, an image enhancement method by saturation and contrast improvement is proposed. Significant change in brightness because of histogram equalization does not give comfort to human vision. Histogram equalization including edge information makes high contrast and suppresses the color distortion. Therefore, the improvement of contrast and saturation provides more natural image. So, it can be applied for LCD, PDP TV such as FPD (Flat Panel Display) system.

5. Acknowledgements

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6. References

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