Contrast Intensification in NTSC YIQ

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Abstract

In this paper, we present a global contrast intensification approach. Contrast intensification is generally carried out as a contrast expansion and after that a tonal intensification is followed. In this paper, we present a new contrast intensification method. First of all, a color image in RGB color space is transformed into YIQ color space. Then, the Y channel of YIQ is contrast restricted. We apply proposed histogram equalization approach on Y channel, or separated each channel of Y, I, and Q channels. The experimental results prove that the processed images look good-natured.

Keywords: *image enhancement, contrast intensification, transform, YIQ channel, color conversion*

1. Introduction

The image intensification is the protocol of processing 2D digital signals so that the results are more suitable to breakdown or demonstrate. The application of contrast intensification extends a wide gamut. The improvement via contrast intensification can be used to many applications such as image and video processing, edge detection, medical image, *etc.* [1-3].

In general, contrast intensification can be categorized as local global approach and local approach [4-6]. The image contrast intensification is important issue in image processing [7-16]. The global approach contains histogram equalization and global stretching which does not constantly guarantee the optimal result when the images are with large contrast variation. In contrast, there are number of local approaches for this issue. There are several examples of contrast intensification. For instance, if we have bright image then we can make the image darkened. These methods can be principally helped by several methods including anisotropic diffusion, non-linear pyramidal techniques, multi-scale morphological techniques, multi-resolution splines, mountain clustering, retinex theory, morphological operators, wavelet transformations, curvelet transformations, *k*-sigma clipping, fuzzy logic, and genetic algorithms.

Contrast intensification intensifies the perceivability of things in the scene by improving the luminosity difference between things and the backgrounds. Contrast intensification is generally carried out as a contrast expansion and after that a tonal intensification is followed. In this paper, we present a global contrast intensification approach. We present the introduction of NTSC color space in Section 2. In Section 3, the contrast intensification algorithm is described. In Section 4, simulation results are shown. Finally, we conclude this paper in Section 5.

2. Color Space: NTSC YIQ

The NTSC color space is adopted in TV in the United States, Canada, Korea and Japan. One of principal merits of NTSC is that grayscale channel is split from color information, and the same signal can be utilized for both 'black and white' or 'color' signals. In the NTSC format, image data comprises of three parts: luminance (Y), hue (I), and saturation (Q). The first component Y, luminance, stands for grayscale information. The other two components build chrominance color information. It is known that the YIQ color space was destined to use human color-response characteristics [17] and therefore more bandwidth is given to I (1.3 MHz for TV system), and less bandwidth is given to Q (0.4 MHz for TV system).

The conversion between RGB and YIQ color space is given below. Three components R, G, B of RGB color space have values ranging from 0 to 1. I component of YIQ has values between -0.596 and 0.596. Q component of YIQ has values between -0.523 and 0.523.

$$\begin{bmatrix} Y \\ I \\ Q \end{bmatrix} = \begin{bmatrix} .299 & .587 & .114 \\ .596 & -.274 & -.321 \\ .211 & -.523 & .311 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} \tag{1}$$

The contrast intensification method is applied in YIQ domain, and the result image is inverse-transformed to RGB with Eq. (1).

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 1 & .956 & .621 \\ 1 & -.272 & -.647 \\ 1 & -1.107 & 1.705 \end{bmatrix} \begin{bmatrix} Y \\ I \\ Q \end{bmatrix} \tag{2}$$

Note that [Y I Q] = [*a* 0 0] when [R G B] = [*a a a*].

3. Image Enhancement Implementation

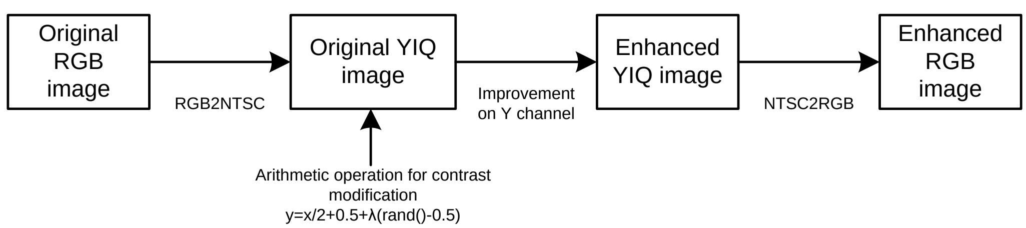


Figure 1. Proposed contrast intensification pipeline

Figure 1 shows the contrast intensification pipeline in YIQ color space. To begin with, the original color image is obtained. This color image includes three color channels, *i.e.*, R, G, and B. This color image is transformed to YIQ color space by Matlab command '*rgb2ntsc*' to obtain the results of Eq. (1). Now the image is consists of three components, Y, I, and Q.

Our scenario is as follows. The given original image is transformed to YIQ color space. The obtained Y channel is modified by Eq. (3). Now the intensity values of each pixel is distributed from -ξ to ξ, where ξ is maximum value determined by λ and Eq. (3).

$$y = \frac{x}{2} + 0.25 + \lambda\left(rand() - 0.5\right) \tag{3}$$

Now, we apply histogram equalization approach (or contrast adjustment method) in Y channel to adjust image's histogram. The main purpose of this method is to increase the global contrast of Y channel because the applicable data of Y channel is outlined by close contrast intensities. After contrast adjustment process, the values are well distributed and this can be noticed on the histogram. The implementation of histogram equalization is performed as follows. Y channel is gray image y, and we assume E_l is the number of events of level l. The chance of an event of a pixel of event level l in the image is calculated as follows.

$$\begin{aligned} c_y(l) &= c(y = l) \\ &= \frac{E_l}{E} \end{aligned} \tag{4}$$

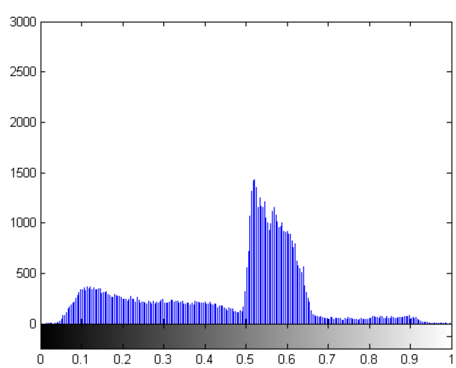
Here, l is bigger than 0 and smaller than entire level number L. Parameter E is the entire number of pixels that image has, and $c_y(l)$ is the histogram of image for pixel value l. The output is normalized to [0, 1]. Then, we clarify the cumulative distribution function (CDF) point to c_y as,

$$CDF_y(l) = \sum_{m=0}^{l} c_y(m)\,. \tag{5}$$

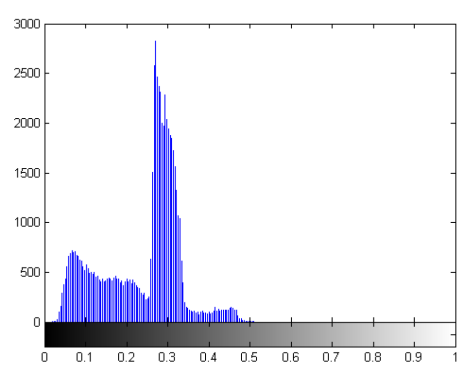
This is accumulated normalized histogram of Y channel. We want to generate a shape of the form $y' = F(y)$ to obtain a new image y', such that its CDF is lined across the value range as shown in Eq. (6), where F outlines the levels into the range [0,1].

$$\begin{aligned} y' &= F(y) \\ &= CDF_y(y) \end{aligned} \tag{6}$$

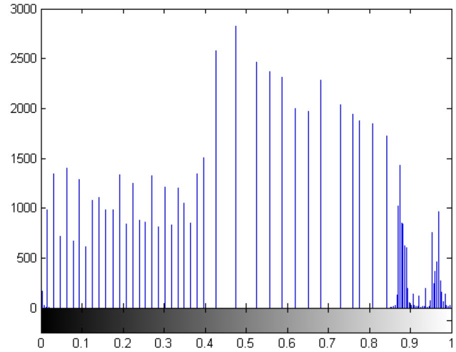
Finally, the enhanced y' signal of Y is merged with I and Q signals and transformed to RGB image by Eq. (2). Figure 2 shows histogram of original image, and its contrast restricted image. The Eq. (6) processed image is shown in Figure 2(c).



(a)



(b)



(c)

Figure 2. Histogram of (a) original image, Original (b) contrast restricted image, and (c) histogram equalized image on Y channel

4. Experimental Results

In this section, we show the effect of our algorithm on LC color images [18], with varying values of the λ and *rand*() command. The original LC images with #30, #38, #44, and #45 are shown in Figure 3. The contrast restricted images are shown in Figure 4. The Y channel of YIQ signal is displayed in Figure 5 and the result images are shown in Figure 6. Figure 7 shows the MSE performance results on 21 images (#30-#50). Simulations are performed to demonstrate the effectiveness of the proposed approach. The qualities are assessed in terms of visual quality and MSE. Figure 3 shows the original LC images #30, #38, #44, and #45. To fairly evaluate performance, we tested four images. Figure 4 shows the contrast restrained LC images, Figure 5 shows Y channel of contrast restrained LC images, and Figure 6 shows the results by the proposed methods.

(a) 

(b) 

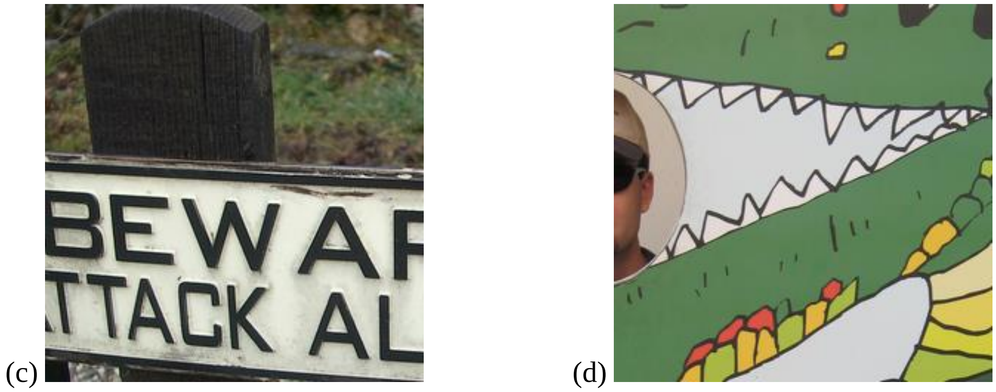


Figure 3. (a) Original LC images #30, (b) #38, (c) #44, and (d) #45

Figure 4. (a) Contrast restrained LC images #30, (b) #38, (c) #44, and (d) #45

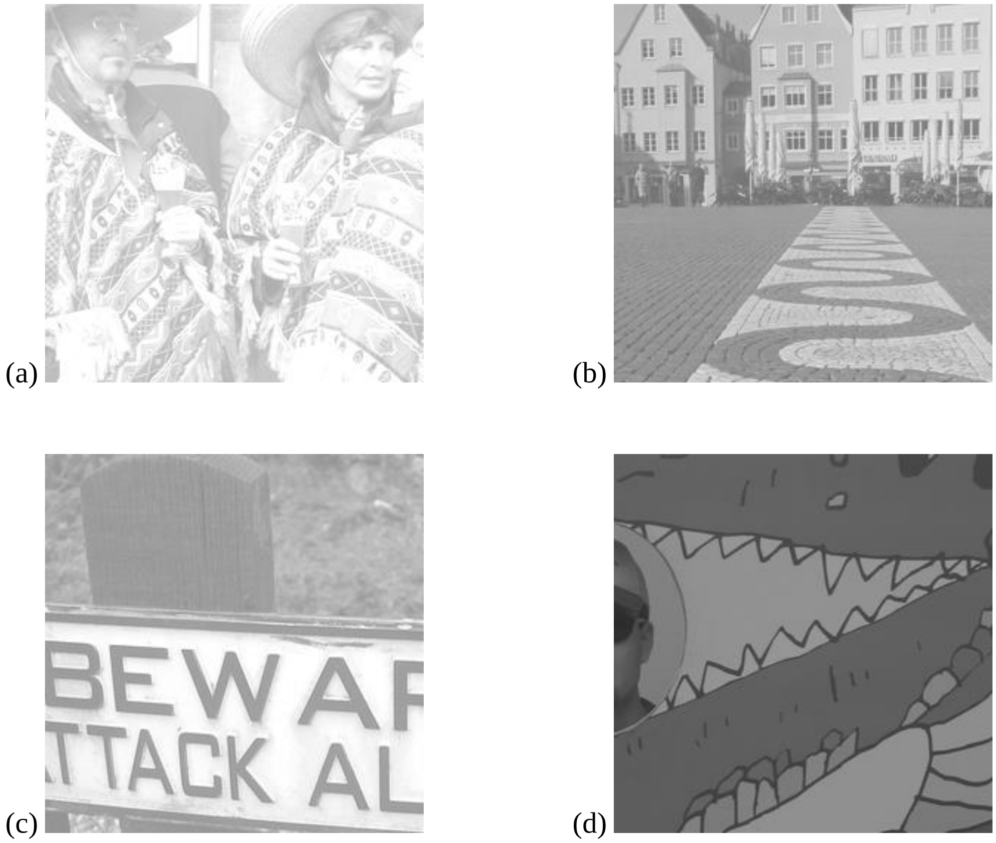
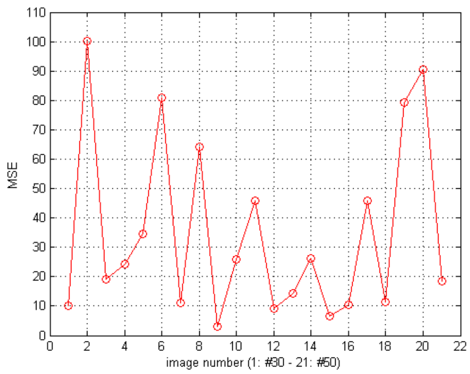


Figure 5. (a) Y channel of contrast restrained LC images #30, (b) #38, (c) #44, and (d) #45

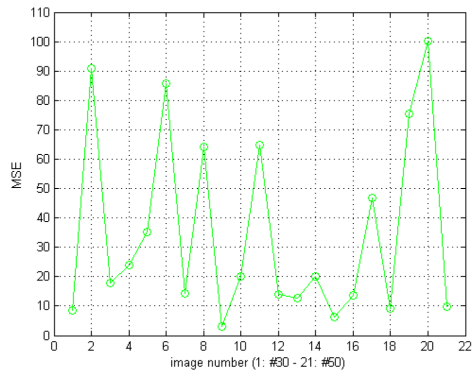
(c) 

(d) 

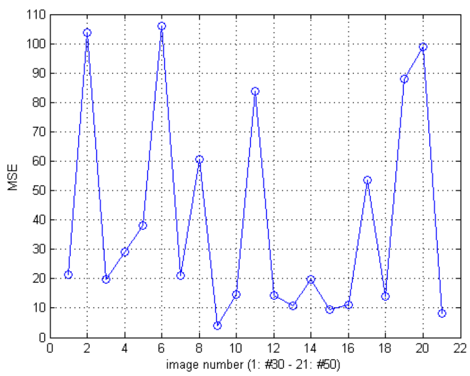
Figure 6. (a) Results by the proposed methods: (a) LC image #30, (b) #38, (c) #44, and (d) #45



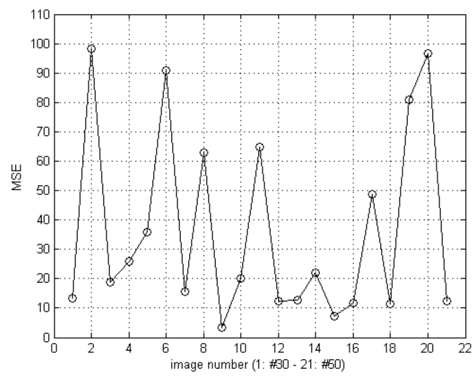
(a)



(b)



(c)



(d)

Figure 7. Performance evaluation in MSE metric: (a) red channel MSE, (b) green channel MSE, (c) blue channel MSE, and (d) color MSE.

Figure 7shows the assessed MSE performance in red channel, green channel, blue channel, and restored RGB color image. The MSE values are different depend on the color channels.

5. Conclusions

A contrast intensification approach was explained in this paper. We first explained how to convert RGB color image to YIQ image with matrix equation. Then we applied proposed histogram equalization approach on Y channel of YIQ. The performance of re-converted RGB image from YIQ looks pleasing.

Acknowledgements

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