



AN IMAGE ENHANCEMENT ALGORITHM BASED ON LIGHT ADJUSTMENT

Mathematics

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ABSTRACT

This paper has investigated the optical propagation process and a number of imaging algorithms. By integrating the retinex theory and the response function of a camera, we proposed a new algorithm for the enhancement of the luminance of images. When building the response function, according to the characteristics of the histogram, this algorithm selects the most representative feature points, connects a series of images in different manners and produces a set of three-dimensional luminance response functions. Through a set of strict evaluations, including the subjective analysis and the objective quality index, this study verified that the proposed algorithm performs well in adjusting the luminance of the images. When compared with the HSL luminance adjustment method, this algorithm also achieves a better performance in the mean square error. Furthermore, subjective analysis confirmed that the images produced by this algorithm are more suitable for people's eyes than the images produced by other image enhancement methods.

KEYWORDS

Image Enhancement, Retinex, Camera Response Function, Histogram, Color Space

INTRODUCTION

In life, the limitations in the conditions of a light source may cause ordinary imaging equipment to produce images that are either too bright or too dark for people's eyes. Though these images are not suitable for normal human vision, their visual effect can be improved by computational methods.

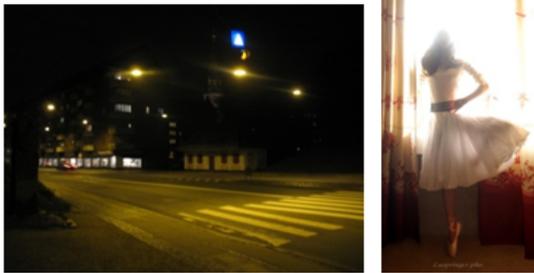


Figure 1 Image in low light and high light condition

The retinex algorithm was proposed in 1971 by Edwin H. Land^[1]. The theory points out that before the human eye observes an image, the display of the object is determined by two main factors: the reflectivity of the object and the intensity of light outside.

Jobson et al.^[2] proposed a single-scale retinex (SSR) algorithm based on the center surround and a multi-scale retinex algorithm (MSR)^[3]. Rahman et al.^[4] proposed a multi-scale retinex algorithm with color restoration (MSRCR), which introduces a color recovery factor for color correction of the image being enhanced.

In 1997, Debevec et al. proposed a camera response function to digitally capture discrete images with different known exposure times through a nonlinear study of a realistic scene^[5]. In 1999, Robertson et al. optimized the exposure time of the camera response function and proposed a polynomial fitting approach to calculate the camera response function^[6].

In this paper, a brightness-enhancing algorithm is proposed, based on the actual imaging effect of the image, and combining the retinex theory with the camera response function.

METHODS

The proposed method consists of the following steps: first, calculate the luminance response function; then, change the brightness of the image.

Calculate the luminance response function

$$x_1 = f(p_1) \quad (1)$$

$$x_2 = f(p_2) \quad (2)$$

P^1 represents the feature point selected from the first picture. X_1 represents the intensity of light corresponding to the point with the luminance response function. P_2, X_2 is the result of another picture.

$$ave = average | x_1 - x_2 | \quad (3)$$

ave is the brightness difference between the two photographs, with the luminance response function.

$$f(j) = x_{1,j} + \alpha(f(j) - x_{1,j}) \quad (4)$$

By utilizing these equations (4), we are thus able to adjust the luminance response function according to the actual situation. Here, α is calculated by using the following formula:

$$\alpha = 1 - \theta(|x_{1,j} - x_{2,j}| - ave) / |x_{1,j} - x_{2,j}|$$

Change the brightness of the image

$$x = f(p) \quad (5)$$

$$x' = x + e \quad (6)$$

$$p' = f^{-1}(x') \quad (7)$$

Equations (5), (6), and (7) represent the process of changing the brightness of an image using a luminance response function. p represents the original image, while p' represents the image after the brightness has been changed. The brightness of the image can be adjusted by freely changing the value of e .

EXPERIMENTAL DESIGN AND RESULT ANALYSIS

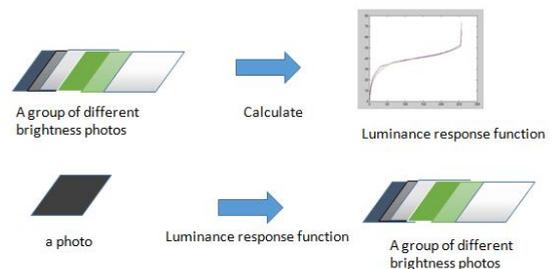


Figure 2. Experiment procedures

For the purposes of this study, a group of photographs were shot with different levels of brightness. The photographs were then used to calculate the luminance response function, according to the algorithm proposed in this paper. We were able to adjust the brightness of the images to any level using the luminance response function. The experiment procedures are shown in Figure 1, above.

The hardware configuration of the PC used to run the algorithm is Intel® Core i5-2400 CPU, 3.1GHz, 8GB The luminance response function algorithm was calculated using MATLAB programming (Windows 7 operating system, Matlab 2013a).

Algorithm comparison



Figure 3. RGB method results

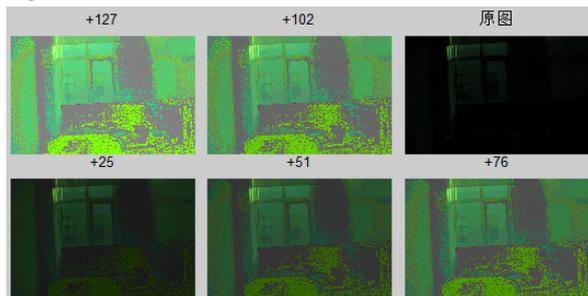


Figure 4. HSL method results

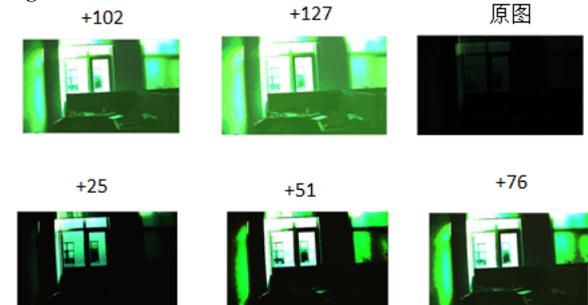


Figure 5. LRF method results

Figures 3, 4 and 5 above show the results achieved when processing a picture with an average luminance of 4 using the RGB method, the HSL method and the luminance response function (LRF) method proposed in this paper, respectively.

In Figure 3, the RGB method adjusts the result only to brighten the picture, but it does not improve the display of the image. In Figure 4, in which the image was manipulated using the HSL method, although some of the contours of the computer and desk can be seen generally on the image, the brightness adjustment severely distorted the colors of the. In Figure 5, however, in which the image uses a luminance response function, both the image sharpness and the color are improved without distortion. Table 1 and Table 2, below, outlines a comparison of the LRF method with the RGB method and the HSL method, further indicating this algorithm's better performance in the mean square error and mean gradient.

Table 1. Comparison of LRF with the other algorithms in mean gradient

	RGB	L fun	HSL
+25	0.282981	1.466916	0.898522
+51	0.282981	2.80825	1.601613
+76	0.282981	6.08921	3.484028
+102	0.282981	9.998169	6.335682
+127	0.282981	14.96479	11.69791

CONCLUSIONS

Even in low light conditions, the algorithm proposed in this paper still provides a better image display. In dark shooting conditions, as were used in our experiment, some of the brighter details in the image are more obvious; as the light gets brighter, the brighter parts of the image tend to lose clarity, however the darker details of the image are still noticeable. The details of the table, for example, are not sufficiently clear when the windows are clear, but when image is brightened, the details of the table gain clarity. It is clear from these results, therefore, that the proposed algorithm is more effective than both the RGB method and the HSL method in enhancing darker images.

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Table 1. Comparison of LRF with the other algorithms in mean square error

	RGB	LRF	HSL
+25	1.822095	0.208289	0.717891
+51	4.210673	0.396583	1.955949
+76	11.24483	0.935284	4.545585
+102	20.20171	1.731796	6.781888
+127	35.61269	6.507672	12.30221