

AUTOMATICALLY ADJUSTING THE COLOR PERCEPTION: A QUALITATIVE ANALYSIS

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ABSTRACT

Image processing is an old concept, being a key issue in high quality pictures. The high quality of pictures can be affected by lightness, weather, time of day when the picture was captured, camera photo, shadows. This paper presents a literature review of some techniques of images processing such as: Autolevels, Contrast stretching, Histogram equalization, Multiscale Retinex with color restoration, Luminance based on Multiscale Retinex. All comparisons are aimed at finding a combination of the techniques such that the output image will be more accurate.

KEYWORDS: Retinex, Histogram, Image enhancements, Autolevels, Luminance

1. INTRODUCTION

The purpose of this paper is to describe the most common problem with the perception of images - that is the imperfect correspondence of the colors and dynamic range seen through viewfinder versus the digital image.

Usually, before being processed, the digital images suffer many types of distortions such as poor contrast, color casts, noise, motion blur. Such being this case, sometimes, the image does not correctly represent the reality, because the color and lightness are not the same with what a human would perceive. Taking this into account, we will analyze different methods for addressing the stated problems and provide a qualitative comparison, identifying the situations in which every method is most suitable in.

2. PROBLEM DEFINITION

Starting from this idea, Land and McCann introduced the “Retinex” model in 1971, as a model for human vision constancy. The human eye adapts to light conditions, such as low light (darkness) or powerful light (sunny), but an image could not adapt to these conditions. In many cases, the images are black or white. For example, the constancy of human vision is that the human eyes perceives a color as being the same color any time of day, even if at sunset the illumination is red and at afternoon the illumination is white. The Retinex algorithms enhance the image using the constancy of human vision, dynamic range compression and color rendition [5].

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The “Retinex” word comes from “retina” and “cortex”; retina is the innermost coat of the eyeball that receives the image produces by the lens and the cortex is the part of human brain that processes information, including visual data. The name of this model tells us the basic assumption of this theory: the human visual system operates with retinal-cortical systems [6].

3. AVAILABLE METHODS

A. Traditional algorithms for the image processing

A.1 Autolevels

The most common algorithm used for image processing is Autolevels, which became popular because of some qualities such as fastness and good results. Many tools have already implemented this algorithm (Adobe Photoshop, JASC PaintshopPro, GNU GIMP) [1].

The Autolevels algorithm uses histogram clipping. The histogram is a graph showing the pixel distribution over the range of possible pixel values, more than 1 and less than 255. For every pixel value (from minimum to maximum), the histogram tells us how many pixels with that value exist in the image. Basically, Autolevels algorithms expand the range of the image, by mapping the smallest value (from the histogram) to min (0), and highest value to max (255). The net effect is increased contrast for most images because they tend to have less dynamic range.

A.2 Contrast stretch

The only difference between Autolevels and contrast stretch is that contrast stretching techniques typically do not clip the histogram [1]. Contrast stretching applies only a linear scaling function to the image pixels. Each pixel P is scaled using the following function:

$$P_{out} = (P_{in} - c) \left(\frac{b - a}{d - c} + a \right)$$

Where:

- a – minimum pixel value that the image type concerned allows [usually, $a = 0$]
- b – maximum pixel value that the image type concerned allows [usually, $b = 255$]
- c – minimum pixel value from input image
- d – maximum pixel value from input image
- P_{in} – the current value of pixel

- Pout – the final value of pixel

This technique has good results if the input image does not contain significant numbers of dark or white pixels simultaneously.

A.3 Histogram equalization

Histogram equalization is used for maximizing the entropy of an image. The scope of this algorithm is to make the darker regions brighter. The algorithm follows the steps:

1. Calculate the histogram for the initial image, with the values from the minimum pixel to maximum pixel from current image.
2. The cumulative distribution function should be calculated. The cumulative distribution function for the current pixel, px , is defined as:

$$cdfx(i) = \sum_{j=0}^i px(j)$$

3. The histogram equalization should be calculated, using the following formula:

$$h(v) = round \left(\frac{cdf(v) - cdf_{min}}{(M \times N) - cdf_{min}} * (L - 1) \right)$$

Where:

- $cdf(v)$ – is the cumulative distribution function calculated in step 2
- cdf_{min} – is the minimum cumulative distribution function calculated in step 2
- M, N – dimension of the image, where M is width and N is height
- L – number of gray levels used (usually 256)
- 4. Create a new image with the histogram equalization calculated in step 2.

B. Retinex theory

B.1 Multiscale Retinex with color restoration

Single scale Retinex (SSR) is a Retinex algorithm developed by Jobson for image processing where the output is determined by the correspondence between the pixel value (center, input value) and Gaussian function (surround, neighborhood) [2]. SSR is defined as:

$$R(x1, x2) = \alpha * \{\log I(x1, x2) - \log[I(x1, x2) * F(x1, x2)]\} - \beta$$

Where:

- R is the output of Retinex algorithm, the output image
- I is the input image
- α is a gain constant,
- β is a offset parameter
- “*” is the convolution operator
- Log is logarithm natural
- $F(x,y)$ is the surround function defined as:

$$\circ Fk(x1,x2) = k * e^{\frac{-(x1^2+x2^2)}{\sigma^2}}$$

○ Where:

- σ is standard deviation
- k – is a normalization factor, defined as:

$$\bullet k = \frac{1}{\sum_{x1} \sum_{x2} F(x1,x2)}$$

The SSR algorithm is not consistent when the initial image has regional and global gray-world violations. Observing this, Jobson has developed a new algorithm: Multiscale Retinex algorithm (MSR), using a color restoration function, which is defined as:

$$Ci(x,y) = \beta \{ \log[\alpha * Ii(x-y)] - \log[\sum_{i=1}^S Ii(x,y)] \}$$

At this algorithm, Jobson added improvements, obtaining the final version of MSRCR [3]:

$$R(x,y) = G * [Ci(x,y) \{ \log Ii(x,y) - \log [Ii(x,y) * Fn(x,y)] \} + b]$$

B.2 Luminance based multiscale Retinex

Multiscale Retinex with color restoration processing enhances image contrast very well, but it often has an undesirable desaturating effect on the image color [3]. The ‘Luminance based multiscale Retinex’ algorithm applies to MSRCR algorithms a color balance for

calibrating the image chromatic [2]. There are 3 channels (red, green, blue) used for getting the input intensity:

$$I_i = \sum_{j=1}^3 I_j = I_{red} + I_{green} + I_{blue}$$

$$I(x, y) = R \times \frac{R}{R + G + B} + G \times \frac{G}{R + G + B} + B \times \frac{B}{R + G + B}$$

The output of the image is the sum between the output intensity for the all three channel (red, green, blue) as below:

$$R_i = \sum_{j=1}^3 R_j = R_{red} + R_{green} + R_{blue}$$

$$R(x, y) = \frac{1}{3} \times \left[\log \frac{I(x, y)}{I(x, y) * F1(x, y)} + \log \frac{I(x, y)}{I(x, y) * F2(x, y)} + \log \frac{I(x, y)}{I(x, y) * F3(x, y)} \right]$$

4. RESULTS AND DISCUSSIONS

We present in Table 1, the comparison between all image processing techniques, described above. Any technique has advantages and disadvantages, so it is very difficult to estimate the best technique [4]. For choosing the best processing image technique, we should account the input image and the expected image output.

Image processing technique	Advantages	Disadvantages
Autolevels	It is a fast and simple method; It uses histogram clipping; Provides good output images for the input images with low dynamic range.	Provides inaccurate output images for input images that have high dynamic range.
Contrast stretching	The visual scene is represented with success.	It does not use clipping, so the image can lose details.

Image processing technique	Advantages	Disadvantages
Histogram equalization	It is a simple and fast technique; The output image is an uniform image.	Preserves the brightness of the input image; It is indiscriminate, increases the background noise contrast, but decreases the usable signal; Produces unrealistic effects in images.
Multiscale Retinex with color restoration	Provides mixed results between dynamic range compression and color constancy; Preserve most of the detail.	Gray level violation problem. Could not get consistently good color results.
Luminance based multiscale Retinex	Improves colors fidelity; Provides the contrast enhancement benefits.	It is a slow and complex method.

Table 1. A comparison including advantages and disadvantages of different methods of image color adjustment

There are activity domains in which an algorithm is better than others. For example, in the medical domain, for enhancing the radiographs of bones, a widely used method is ‘Histogram equalization’, because it is a technique useful in images with bright or dark foregrounds and backgrounds and the usable data of the image has close contrast values.

Autolevels and contrast stretching are good techniques if the images do not contain many dark and bright pixels in the same time. In this case, the output image is identically with the input image.

Retinex algorithms are more accurate than histogram algorithms, but they lose many information and details, having difficulty with keeping the visual quality of colors. For this, it was observed that using an algorithm with histogram technique (Autolevels, Contrast stretching, Histogram equalization) before the Retinex algorithm can lead to more accurate output images, when speaking about terms of visual quality.

Another advantage for using a combination between Histogram methods and Retinex methods is when processing images that are situated at the limits of the test scenarios, when using a single method has failed. For this, if one method fails and the other succeeds, the output image is more accurate than the output image obtained when using only one algorithm.

5. CONCLUSIONS

External factors, such as weather, light and camera are very important for picture accuracy, as they can distort the reality and the pictures can lose information about real image data.

Over the time, various methods for processing unclear images were developed, some of them analyzing image histograms, while others analyzing human vision constancy and dynamic range compression. All techniques are good on specific test scenarios, but all of them may fail when the input is not the expected one.

According to the analysis described above, if we want to enhance the image quality, firstly, you should stabilize some input criteria. For example, if the image does not have many dark and bright pixels simultaneously, Autolevel or contrast stretching methods can be used. There are currently no methods to performing good result regardless of the type of input images.

6. SUGGESTIONS FOR FUTURE WORK

The next step after this qualitative comparison is to perform a quantitative analysis of the presented method. The metrics can include both image-related parameters (noise, color distribution etc.) and parameters that indicate runtime performance (complexity, CPU and memory usage). Also, for processing very large images (for example, satellite maps), we can research the potential for transforming the algorithms into parallel ones.

The advances in color perception analysis may well contribute in other research domains which rely in color perception and correction, like: sense substitution [7], specular highlight removal [8], image color reduction [9], binarization [10] and image segmentation [11].

ACKNOWLEDGEMENTS

The authors would like to thank Professor Costin-Anton Boiangiu, teaching assistant Mihai Zaharescu and engineer MSc Andrei Tigora for their great support and assistance with this paper.

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