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Color Constancy Algorithms in Practice

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Abstract

In the demonstrative session, the effect of applying color constancy algorithms is going to be shown in two ways. The first includes the processing of reference images, commonly used for benchmarking and testing. The second mode is the operation in real-time, processing a continuous video stream. After a qualitative appreciation of the effects, the computer vision developer can then propose the inclusion of such algorithms as a preprocessing step in complex tasks.

1. Introduction

Color constancy is an important cue for computer vision tasks [6]. Application areas include image processing, feature extraction [5], color appearance models [3] and human-machine interaction [8]. Because the perception of color depends on intrinsic characteristics of the surfaces and the color of any light source, in a color-based system, the effects of the light sources must be filtered.

Briefly, color constancy is an ability of the human visual system, where the brain and retina are capable of determining the color of an object under different lighting conditions [9]. Also referred as white balance by photographers, color constancy research using algorithmic and instrumentation approaches has been important in the computer vision field. Nonetheless, results show there is no single algorithm that can solve any problem, mainly because the distribution of the light sources usually is unknown. Besides, all we perceive and can measure is the product of the reflectance and the amount of light upon the object. As an example, let us imagine we look a scene with a number of objects under a blue light as the one in Figure 1. Despite of this dominant color, our visual system is able to correctly recognize the color of objects.

2. Color constancy algorithms

A number of color constancy algorithms have been proposed [2]. We can mention the White Patch Retinex, the Gray World assumption, the variant of Horn, the Gamut-based and the Correlation by Color algorithms, among others. Two basic algorithms are described here, although other are going to be included in the demonstration.

(a) (b)

Figure 1. (a) An object under a blue lighting, and after color constancy (b).

2.1. White Patch Retinex

Based on the retinex algorithm proposed by Land and McCann [7], the simplified version of the algorithm is usually included in commercial software. The algorithm is based in considering the highest value in each color channel as the white representation for the image.

Let us assume that $I(x,y)$ is the intensity of a pixel in an image or a frame, $G(x,y)$ is a geometry term, $R_i(x,y)$ the reflectance, L_i is the intensity the current illumination, and i is one of the color channels in the image. Eq. 1 gives the relationship for the color intensity

$$I_i(x,y) = G(x,y)R_i(x,y)L_i \tag{1}$$

Assuming $G(x,y) = 1$ and $R_i(x,y) = 1$, the relation in Eq. 2 applies and, then we can say that the color $c_i(x,y)$ may be represented as in Eq. 3.

$$I_i(x,y) = L_i \tag{2}$$

$$c_i(x,y) = I_i(x,y) \tag{3}$$

Computationally, this white patch is found searching for the maximum intensity in each channel, as indicated in Eq. 4.

$$L_{i,max} = max\{c_i(x,y)\} \tag{4}$$

Later, we must scale all pixel intensities according to these values, using Eq. 5.

$$o_i(x,y) = \frac{c_i(x,y)}{L_{i,max}} = G(x,y)R_i(x,y) \quad (5)$$

The White Patch Retinex can be improved. We use the same initial assumptions, but instead of using the pixel with the highest intensity we can use the intensity value representing all the pixels higher to a percentage of the total of pixels. This method is used in [4] for shadow removal.

$$L_i = c_i(j_i) \quad (6)$$

For the selection of the j_i some conditions must be fulfilled

$$pn \leq \sum_{k=j_i}^{nb} H_i(k) \; y \; pn \geq \sum_{k=j_i+1}^{nb} H_i(k) \quad (7)$$

where $H(k)$ in the channel histogram, j the index of the corresponding intensity bin in the histogram, and pn is a percentage (usually about 1% [2]) of the total of pixels in the image.

2.2. The Gray World assumption

Proposed by Buchsbaum [1], it is a well known approach, used as reference for other algorithms. In its simplest version, it is assumed that the information in the average of each channel of the image is the representative gray level.

The first step to do, is the computation of the average color in the image, as indicated in Eq. 8

$$a_i = mean\{c_i(x,y)\} \quad (8)$$

Once this global value in known, we proceed to compute the color of the light source, L_i. We need to use a geometry factor, $E[G]$, representing the orientation between the object and the camera. Assuming a perpendicular orientation, we simplify and use $E[G] = 1$. Eq. 9 describes the computation of the factor f to be used later in Eq. 10.

$$f = \frac{2}{E[G]} = 2 \quad (9)$$

$$L_i \approx \frac{2}{E[G]} a_i = f a_i \quad (10)$$

Once the color of lighting is known, we can compute the output value using $c_i(x,y) = G(x,y)R_i(x,y)L_i$. The output value is given by Eq. 11.

$$o_i(x,y) = \frac{c_i(x,y)}{L_i} = \frac{c_i(x,y)}{f a_i} = G(x,y)R_i(x,y) \quad (11)$$

3. Discussion

The adequate use of a color constancy method largely affects the performance of subsequent image analysis tasks. Nonetheless, choosing the appropriate one depends on the particular image under analysis. By example, the White Patch Retinex shows a good performance when a predominant color or lighting is present or when the image is dark. The Gray World assumption is well suited for situations when a number of colors or specularity are present. Under different lighting conditions other color constancy algorithms should be considered.

For disclosure purposes, the effect of applying a number of color constancy algorithms is going to be demonstrated for static and dynamic scenes.

After the demonstrative session, we hope the audience consider the use of color constancy methods as a preprocessing step when developing computer vision applications.

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