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A Color Cast Detection Algorithm of Robust Performance

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Abstract—**In order to overcome the limit of traditional methods in image cast detection, a new cast detection approach with robust performance is presented. The algorithm by using digital image analysis is used to analyze the characteristics of the image itself. Especially the algorithm introduces image texture information to cast factor K. The new technique of evaluating cast detection not only is able to accurately detect cast images, but also to avoid taking normal images estimate into cast images, and enhances the detection accuracy and reliability. The performance is more robust. The experiment results show that by testing many different images, the proposed method and the subjective evaluation results are in good agreement.**

I. INTRODUCTION

THE color is an important feature of images, including some visual information. The image analysis is often on the basis of the image color information. And the color information has an important significance in the image segmentation, object detection and recognition, images retrieval, etc.

However, when the imaging equipment is affected by the exoteric luminance and the physical features of the sensors, the color of the images captured by the imaging equipment may have a deviation with the real color of the object surface. It is just cast.

With the construction of safe cities, the popularization of surveillance equipments improves the security forces. At the same time it brings about a big challenge to the maintenance of the surveillance system. The system of video quality diagnosis is a typical application of IVS in security system maintenance. Its effective detection to fore-end video equipments can help people cope with the emergency and ensure the normal operation of the video surveillance system effectively. Cast detection is an important part in video quality diagnosis.

On the research of face detection and video retrieval, most algorithms are based on the analysis of image color features. When the color cast appears in the image, the performance of the algorithm may drop evidently. The algorithms may even become invalid.

At present some progress has been made on the research of cast detection. Some representative cast detection methods include histogram statistics [1], gray world method [2], the white area method [3], neural network approach [4] and prior knowledge method [5] and so on. These algorithms all have some boundedness that the color cast cannot be detected correctly under any circumstances and the level of color cast cannot be estimated accurately. For example, the whole color expression of the image can often be obtained from histogram statistics, but the method based on histogram statistics cannot judge the color cast accurately for that the causes of color cast are complex. The gray world method and white area method have a scene limitation. For example, the background of blue sea and sky may affect the judgment to the real color of the image by gray world method; if the detected image has no white area, the detection result may have a distortion by white area method. The neural network approach and prior knowledge method have big limitations as they must judge by learning and accumulation or prior knowledge.

In this paper, we have proposed a color cast detection method based on image analysis. The method doesn't need knowledge accumulation or prior knowledge. It has a better accuracy and reliability. It can also estimate the level of color cast.

II. THE CAST DETECTION METHOD BASED ON IMAGE ANALYSIS

A. Overview

The algorithm in this paper is not based on any idealized conditional assumption. It doesn't utilize any prior knowledge of cast images. We just analyze the images using the own features of the cast images, so it has a universal applicability. The main steps are as follows:

1)Step 1: Transform the input images from RGB space to Lab space. The distance among the colors computed in Lab space is consistent with the distinction from practical perception. The Lab color is composed of luminance component L and 2 chrominance components: a and b.

2)Step 2: Compute the average chrominance D of the images and the distance D between the chrominance centers.

3)Step 3: Transform the color image to the grayscale. Compute the mean value and variance of the grayscale.

4)Step 4: Compute the cast factor K' according to equation (10) to judge whether the cast occurs and measure the level of the cast.

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B. Color Space Transformation

To measure the deviation degree between the 2 colors, we need to choose proper color space [6] at first. The most common space is the RGB space. But when we describe the differences between the 2 colors by European distance, the RGB space has some severe problems as the computed distance between the 2 colors cannot correctly represent the real difference from our practical perception and has some shortcomings as non-intuition, uneven, equipment relied. In this text we use CLE Lab color space established by CIE in 1976. The distance between the colors computed in the color space is consistent with the distance from our practical perception. The Lab color is composed of luminance component L and 2 chrominance components as a component (from green to red) and b component (from blue to yellow). The transformation from RGB space to Lab space can be realized in 3 steps.

Step 1: transform the RGB space of 24 bit true color to sRGB (standard red green blue) space. sRGB space as a standard RGB space is a widely used color space in computers.

Step 2: transform the sRGB space to XYZ space [7] through linear transformation. XYZ space is a transitional color space without equipments relied.

Step 3: transform the XYZ space to Lab space. The specific equations are as follows:

$$\begin{aligned} X &= 0.412453\times R+0.357580\times G+0.180423\times B \\ Y &= 0.212671\times R+0.715160\times G+0.072169\times B \\ Z &= 0.019334\times R+0.119193\times G+0.950227\times B \end{aligned} \tag{1}$$

$$\begin{aligned} P &= X/0.9505 \\ Q &= Y/1.0 \\ R &= Z/1.0891 \end{aligned} \tag{2}$$

$$\begin{cases} if \quad (\mathrm{Q}<0.008856), & then: \ \mathrm{L}=903.3\mathrm{Q}; \quad \mathrm{Q}_1=7.787Q+16/116.0; \\ else & \mathrm{L}=116\mathrm{Q}^{1/3}\ \text{-}16; \quad \mathrm{Q}_1=Q^{1/3}; \end{cases}$$

$$\begin{cases} if \quad (\mathrm{P}<0.008856), & then: \quad \mathrm{P}_1=7.787P+16/116.0; \\ else & \mathrm{P}_1=P^{1/3}; \end{cases} \tag{3}$$

$$\begin{cases} if \quad (\mathrm{R}<0.008856), & then: \quad \mathrm{R}_1=7.787R+16/116.0; \\ else & R_1=R^{1/3}; \end{cases}$$

$$\begin{aligned} \mathrm{a} &= 500.0\times(\mathrm{P}_1 - \mathrm{Q}_1) \\ \mathrm{b} &= 200.0\times(\mathrm{Q}_1 - \mathrm{R}_1) \end{aligned} \tag{4}$$

C. Cast Factor K

Through the comparison and analysis to vast normal images and cast images, the cast of digital images is not only directly related to the mean value of the image chrominance, but also related to the distribution character of the image chrominance. If the chrominance distribution of 2-dimension histogram in the ab chrominance coordinates plane is mainly single peak value or centralized, and the mean value of the chrominance is biggish, there usually exist color cast. The bigger the mean value of the chrominance, the more severe the cast is. However, if the chrominance distribution of the 2-dimension histogram in the ab chrominance coordinates is evidently multi-peak and dispersive, the level of cast may reduce immensely so far as to no cast. Therefore, we measure the cast level through the image chrominance divided by the distance among the chrominance centers. We call the ratio as K factor. The computing method is as follows:

$$mean\_a = \frac{\sum_{i=1}^{i=H}\sum_{j=1}^{j=W} a(i,j)}{H\times W}$$

$$mean\_b = \frac{\sum_{i=1}^{i=H}\sum_{j=1}^{j=W} b(i,j)}{H\times W} \tag{5}$$

$$D = \sqrt{mean\_a^2 + mean\_b^2} \tag{6}$$

$$M\_a = \frac{\sum_{i=1}^{i=H}\sum_{j=1}^{j=W} |\, a(i,j) - mean\_a \,|}{H\times W}$$

$$M\_b = \frac{\sum_{i=1}^{i=H}\sum_{j=1}^{j=W} |\, b(i,j) - mean\_b \,|}{H\times W} \tag{7}$$

$$M = \sqrt{M\_a^2 + M\_b^2} \tag{8}$$

$$K = D/M \tag{9}$$

In the equations, H and W are the resolutions of the images. When the cast factor K is bigger than a threshold, the cast exists in the image. The bigger the K value, the more severe the cast is.

D. Cast Factor K'

However, in practice (as figure 5 ,6 and 7) we can find that a normal image with single scene may be misjudged as cast image through only the K value. To correctly judge whether the image is cast, the cast factor must be modified through equation (10) rather than equation (9).

$$K' = \frac{D}{M \bullet \max(\left|\min((\sigma^2 - A),1)\right|,1)} \tag{10}$$

In the equation, A is the threshold to judge whether the texture information of the image is rich. It can be altered according to the practice. σ^2 as the variance of the image is an important symbol reflecting the rich level of the image information.

$$\sigma^2 = \frac{1}{W \bullet H}\sum_{i=1}^{H}\sum_{j=1}^{W}\left(f(i,j),\mu\right)^2 \tag{11}$$

In the equation, $f(i,j)$ is the grayscale value of pixel (i,j). μ is the mean value of the grayscale values.

$$\mu = \frac{1}{W \bullet H}\sum_{i=1}^{H}\sum_{j=1}^{W} f(i,j) \tag{12}$$

When the K' is bigger than or equal to the default, the image is cast. And the bigger the K', the more severe the cast is. When the K' is less than the default, the image is normal. K' can be altered according to the practice.

III. EXPERIMENTAL ANALYSIS

To verify the performance of the algorithm in cast detection, we test the pictures from cameras in practice and different facets of pictures downloaded from the Internet.

The process is done on a computer with Windows XP, Intel Pentium dual-core processors of 2.60 GHz, RAM of 2.91GB. The algorithm is written in C++. In the test, In the equation (10), the A is set as 2000 and can be altered according to the practice. For CIF image, 25 frames can be processed in a second. Basically it can meet the real-time processing effect. Comparing to the K, K' in figure 1, 2, 3, 4, 5, 6, and 7 respectively, the judgment of whether the image is cast through K' is more accurate and suitable than the K value. By this way we can not only detect the cast image (figure 1, 2, 3 and 4), but also recognize monochrome image avoiding the misjudgment from monochrome image to cast image (figure 5, 6 and 7). Compared with the figures below, the algorithm in this text can distinguish the normal images and cast images. From table I, we can see that the algorithm in this paper can better meet with the subjective results from our eyes and has a better robustness.

Fig.1. Color Cast

Fig.2. Color Cast

Fig.3. Color Cast

Fig. 1. $K = 2.0771$ $\sigma^2 = 3302.6$ $K' = 2.0771$

Fig. 2. $K = 3.9495$ $\sigma^2 = 2789.8$ $K' = 3.9495$

Fig. 3. $K = 7.9613$ $\sigma^2 = 2109.8$ $K' = 7.9613$

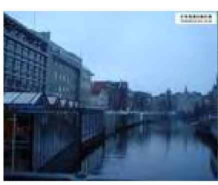

Fig. 4. Color Cast

Fig.5. Color Normal

Fig.6. Color Normal

Fig. 4 $K = 3.6372$ $\sigma^2 = 5142.1$ $K' = 3.6372$

Fig. 5 $K = 3.3655$ $\sigma^2 = 1849.8$ $K' = 0.0018$

Fig. 6 $K = 16.2358$ $\sigma^2 = 217.3742$ $K' = 0.0747$

Fig. 7. Color Normal

Fig. 7 $K = 19.8369$ $\sigma^2 = 60.1565$ $K' = 0.3298$

TABLE I
COMPARISON RESULTS OF EXPERIMENTATION

Figure	Judgment from K	Judgment from K'	Judgment from eyes
Fig.1	cast	Cast	cast
Fig.2	cast	Cast	cast
Fig.3	cast	Cast	cast
Fig.4	cast	Cast	cast
Fig.5	cast	Normal	normal
Fig.6	cast	Normal	normal
Fig.7	cast	Normal	normal

IV. CONCLUSION

The algorithm in this paper is not based on any idealized conditional assumption. It doesn't utilize any prior knowledge of cast images. We just analyze the images using the own features of the cast images, so it has a universal applicability. Experiments show that for any scene images, the algorithm in this text can achieve an accurate detection result. If the algorithm can be applied to the detection of fore-end equipments, it can help find the equipment faults and remind the staff to maintain or change the equipments in time. It can guarantee the normal operation of video surveillance effectively and offer security guarantee to the latter part fault management and maintenance of large-scale surveillance system.

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