将图像分区域，计算每个区域的一个加权值，然后计算整幅图像Cr和Cb的加权平均，依据这个加权平均的偏移对图像进行矫正

A Method Of Automatic White Balance Using Fuzzy Logic

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Abstract

In the processing of digital image, automatic white balance is used to color reproducing under alternative color temperature. This article provided a method of AWB control using fuzzy logic from which we can find the advantage of fuzzy logic in digital image processing

I. Color Difference Signals Under Different Light Sources

According to CCIR601 standard, the digital signals of a color image can be decomposed into three components Y, Cr, and Cb, where Y is the intensity, and Cr, Cb are the color components. The pixel data Y, Cr and Cb are accumulate over an image frame. Illuminated with a standard light source, a monochromatic object will be on a nominal position on the Cb-Cr coordinate. However, with different light sources or light intensity, the position will deviate toward Cb (indicate bluish) or Cr (reddish) coordinate. Some of the experimental results are summarized in the Figure 1. The experimental results depict that:

1. A dark color has less deviation from nominal position under different light sources, as opposed to the bright color, where the deviation is significant on the Cb and Cr components.

2. When a white object is illuminated with different light sources, the slope of deflection, i.e. the ratio of Cr to Cb, r = Cr/Cb is about between –1.5 and –0.5.

3. At high luminance, the color components are easy to be saturated; while at low luminance, the color components become colorless.

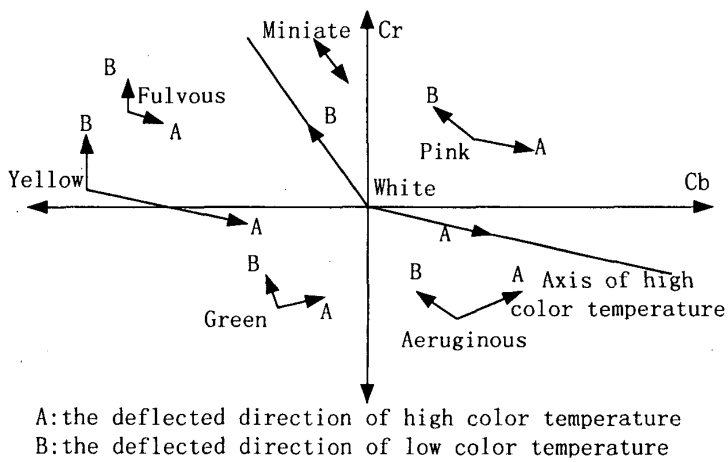


Fig .1 the experimental data of colors under different light sources

II. The Automatic White Balance Algorithm Using Fuzzy Logic

A frame of image captured with a CCD camera can be divided into 8 segments for weightings. Figure 2 shows two types of segmentation. The averages of Cr and Cb components of all pixels within each segment are calculated, and then weighted under fuzzy control means. Based on experimental results, the fuzzy rules were described below:

1. At high luminance, the color components are easy to be saturated, while at low luminance, the color components become colorless. Hence, the Cb and Cr will be weighted with small value under the conditions of high end and low end luminance.

2. The averages of Cb and Cr for each segment are

weighted less for dark colors than bright colors.

3. When a large object or a background occupies more than one segment, its color will dominate that segment. The r-value will be similar among adjacent segments. On this case, the given weighting for that segment is small in order to avoid over compensation on the color of the picture. Otherwise, if r is very different from the adjacent segments, and is about between −1.5 to −0.5, the given weighting is large.

The image captured by a CCD camera can be converted into digital data. Those raw data can be processed with a DSP/IC (digital signal processor integrated circuits) to implement color conversion, interpolation, and coding. The result digital output consists of Y, Cb, Cr components for each pixel. The full image frame then can be stored in an image buffer and the Algorithm can be executed in a computer.

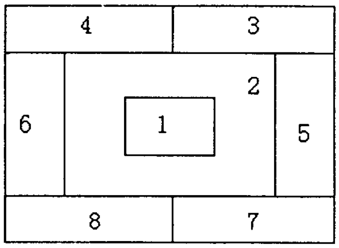
As discussed before, the image is divided into 8 segments. The averages of Cb and Cr for each segment are calculated. Then the weighting factors for each segment are determined, based on the fuzzy control means, to calculate the evaluation Cb' and Cr' of the whole image frame. The Cb' and Cr' indicate the deviation of the image color from the white balance point. These values are employed to obtain the gains for Cb and Cr of each pixel. The averages of adjusted Cb and Cr are calculated. If the result is not close to the white balance point, the iteration will be performed.

III. The Algorithm Description In Detail

In the algorithm discussed before, the most important point is the deciding of the weighting values. In our experiment, we adopt the second segmentation shown in Figure 2.

1. The effect of luminance to weighting value

According to the fuzzy algorithm, the weighting value goes to the minimum at high luminance and low luminance. We can attach the effect of the luminance to a parabola function. The function form looks like $y = ax^2 + bx + c$, in which x is the average of the luminance of every segment. The function goes to the minimum 0 when the luminance goes to the maximum (x_{max}) or the minimum (x_{min}) in an image, and goes to the maximum 1 when the luminance goes to (xmax+xmin)/2. Accordingly, we can get the function by working out the a , b and c.



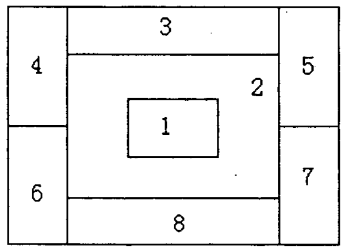


Fig. 2 Division Of Frame

2. The effect of chroma to weighting value

A method drawn from fuzzy weighting filter is shown below:

Adopt B[i] as the estimated measure, to indicate the average chroma distribution of each vicinal segment, as:

$$B[i] = \frac{\sum_{1}^{N} d_{ij}^{2}}{N-1}$$

in which $d_{ij}^2 = (c_i - c_j)^2$,c_i is the color difference Cr[i] or Cb[i].

Subject function μ_{ij} indicate the consistent degree of the vicinal c_j and c_i. μ_{ij} is a decreasing function about the standard remaining value and can be expressed with a exponent function. Accordingly, the weighting value can be expressed as:

$$weight[i] = \frac{\mu_{ij}}{B[i]}$$

The advantage of this algorithm is that the comparability and relativity of the chroma signal nearby has been calculated.

3. The weighting values after synthesized

After all, it is to be calculated that the weighting value goes to the maximum when Cr/Cb is between –1.5 and 0.5, then the more close to –1.5~-0.5 Cr/Cb goes, the more the weighting value goes, and the more expectation is meet. We adopt the function as shown below:

$$y1 = \exp(\ 1.0 / 1 + (cr[i] / cb[i] + 1.5)^2) \times$$
$$\exp(\ 1.0 / (1 + (cr[i] / cb[i] + 0.5)^2)$$

in which i=0,...,7,cr[i] and cb[i] each is the average of the chroma of every segment.

After synthesized the effect of luminance and chroma, We get the weighting values of every segment:

Weight[i]=weight[i]*y*y1

4. Automatic white balance processing

After weighting every average of color difference cr[i] and cb[i] of every segment ,and after getting the average of it, we get the average color difference: crq and cbq of the whole image. We can obtain a white balance by approach the crq and cbq to the origin point.

IV. Result

The algorithm was implemented in circuit and has been tested. The performance on white balance is significantly improved. This method uses the picture segments with different weightings, with different weightings, which minimize the color effect of large objects and background. The fuzzy control rules were obtained with experimental data. Therefore, using these rules for gain determination gives the optimal performance on white balance.

Reference:

[1] YoungSik Choi, Roghu Krishhnapuram, "A Robust Approach to Image Enhancement Based On fuzzy Logic", IEEE Transactions on Image Processing, Vol. 6, No. 6, June 1998

[2] Yung-ChengLiu, Wen-Hsin Chan and Ye-Quang Chen, " Automatic White Balance for Digital Still Camera", IEEE Transactions on Consumer Electronics, Vol. 41, No. 3, August 1996.