3—35 Tinting Component Extraction from Gray-scale Image for Color Estimation

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Abstract

The authors have been studying color estimation of gray-scale image. The problem of this study is defined as an ill-posed problem, because a luminance to arbitrary color is uniquely fixed but the luminance corresponds to plural color-values. In this paper, tinting-component (as white mixed value) estimation method from gray-scale image is proposed based on statistics. This method acquires tinting value that corresponds to input luminance by using tendency of one color vector's pair of luminance and tinting value. In this method, a few of sample image could be estimate resemblance under the situation that appearance probability of any color value is equal. Then, this method is expected the estimation with higher precision by making suitable adjustment based on the characteristics of input image.

1 Introduction

Restoring colors of gray-scale images is theoretically impossible. However, there are many demands for coloring gray-scale images such as archeology that handles a historical photograph, and the field of amusement that handles a monochrome movie, and so on. In order to satisfy those demands, there were some methods of painting a color a glay-scale image artificially. However, there were many problems in color decision process. The coloring depends on subjectivity (like a memory, an aesthetic sense) and refer to present color photo.

Recently, "COLORIZATION" has been studied as a trial to automate coloring to gray-scale image [1],[2]. This is an approach for estimating colors of whole image by giving some partial color in advance, or by presenting similar color image. Though some effective results were reported, these are not complete automation because it prepares an image, or giving a color in advance by subjective sense is essential.

The authors have been proposed an objective color estimating model useless previous information [3] - [5]. According to Ostwald color system, a color can be expressed by the mixture of white, black and the pure color. Furthermore, it expects that there is correlation in volume of black and white empirically with luminance. Then, the estimation method of the image consisting of tri-components were examined by establishing the following color's interpretation: the shading-component means black, the tinting-component means white, and the pure color component shows hue. In Ref.[3], an estimation method of pure color by calculating hue that copes with each luminance based on the probability density was proposed. In Ref.[5], the estimation method of shading-component was proposed based on the statistical characteristics.

In this paper, an estimation method of tinting-component is proposed. Though the method referred to shading-component's one, results were shown not satisfied precision the case of shading's method and causees are considered.

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2 Establishment of the problem

In this section, we make a problem clear in this paper.

Let y be a liminance corresponding to a color vector (R, G, B). Then, y can be derived by the following equation:

$$y = 0.299R + 0.587G + 0.114B. \quad (1)$$

From Eq.(1), to solve a color from luminance is an ill-posed problem. However, colors become shade by mixing black, and bright by mixing white. It can be expected correlation between black and white mixture and luminance because such a mixture reflects on luminance. The mixing style of (pure color + white + black) is proposed as Ostwald-color-system, and relations with additive mixture of color can be expressed by Fig.1.

Black appears by lack of the light, and it can be calculated as

$$1 - \max(R, G, B) \quad (2)$$

in the Fig.1. In the same way, white that appears by the same quantity mixture as RGB is shown with

$$\min(R, G, B). \quad (3)$$

And a value to coincide in the Eq.(1) becomes candidate of left primary color based on statistical estimation of black and white. Then, it can get a pure color (hue) by the ratio of two colors.

Usually, there is diffuseness of neighborhood pixels' color information of image and diffuse areas of them are recognized with the human perception as image regions. This notion applies to gray-scale image. If adjacent pixels' luminance does not differ suddenly, we will recognize as an image region of gray-scale image. Without clue except for luminance, we will sensuously recognize fixed hue in the region. Therefore, candidate

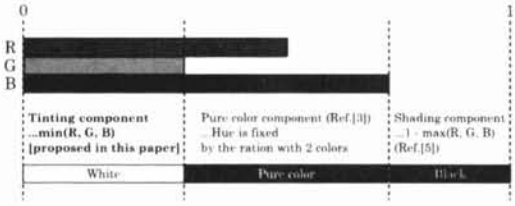


Figure 1: Definition of tinting-component.

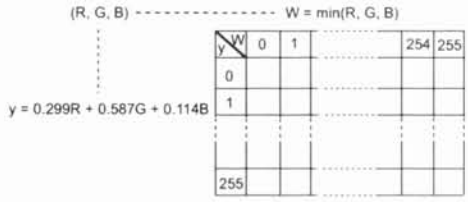


Figure 2: Luminance tint frequency table.

of left primary color value restrict to hue fixed in each region of gray-scale image based on human perception.

First of all, high-precision estimating of shading and tinting-component is important getting rare difference result in perception. The evaluation of estimation result depends on a human harmony sense. If it process to gray-scale image converted from color image, to get "same" or "resemblance" harmony is desirable in comparison between estimation result and color image. In Ref.[6], human recognize difference of lightness "same" with $0-1.5\%$ and "resemblance"with $5-15\%$. Therefor, estimation precision is required 36.5(dB) in "same",or 16.5(dB) in "resemblance". In this study, methods are established by using Ref.[6] as the evaluation base of the estimation result to satisfy the benchmark of "resemblance".

3 Proposal of estimation method

In related preceding study [5], the answer of shading-component was gotten in "resemblance". In this paper, tinting-component is estimated by referring to the method.

3.1 Definition of tinting-component

In Sec.2, tinting-component was shown as mixture of white. Fig.1 showed that colors without tinting-component are pure color or shade color[1] . If shading and tinting-components can be extracted suitably from gray-scale image, remainds show pure color at most. Then, more suitable hue will be estimated by Ref.[3].

3.2 Estimation of tinting-component

In this paper, estimation of tinting-component is tried by setting up a vote ticket based on the corresponding of gray-scale picture's luminance and tinting-component. The proposed method for estimation consist of two processes as follows.

[Process 1] Preparation of corresponding table

Calculate respectively luminance y by Eq.(1) and tint value W by Eq.(3) from each (R, G, B) vector, and make out luminance tint table ($0 \leq y, W \leq 255$ as $8bits$ ordinary used in computer). Figure 2 shows a luminance tint table's image.

[1] Color that mixed black with the pure color.

[Process 2] Setting vote ticket

Setup of vote ticket uses the following two kinds of methods paid attention for validity of estimation result, one side is average of corresponding tendency, other side is the most frequent value of corresponding.
(Method A) Statistical expectation of W for each y.
(Method B) Mode of W for each y.

From Fig.2, statistical expectation of method A is computed by

$$\frac{\sum_{W=0}^{255} W \cdot n_W^{(y)}}{\sum_{W=0}^{255} n_W^{(y)}}. \tag{4}$$

Here, $n_W^{(y)}$ means frequency of W to optional y.

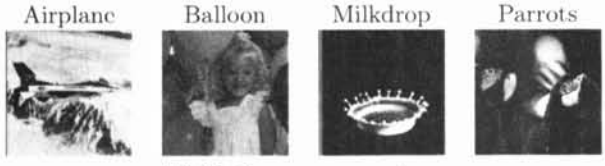
In the experiment, two kinds of estimation results are compared with a correct answer (tinting-component acquired from original color image) to adopt high precision in the result as a estimation method.

4 Verification of proposal method

4.1 Specifications of experiment

The experiment used images of SIDBA (Standard Image Data-BAse)[2] . In Fig.3, it is shown that (a) gray-scale images used in this experiment, and (b) the answer of tinting-component extracted by Eq.(3) from original color source.

(a) Gray-scale picture



(b) Tinting component

Figure 3: Image data for experiments.

[2] At `http://www.sp.ee.musashi-tech.ac.jp/app.html`.

4.2 Tinting-component extraction

This experiment verified whether tinting-component was extracted from gray-scale image suitably. Tinting-component estimated by using two vote ticket methods A and B defined in Sec.3 was compared with correct answer (Fig.3(b)).

Estimation results are shown in Table 1 with estimation precision SNR[dB](p-p/rms) by l^2norm to tinting-component of the correct answer . From the result, suitable setup method of vote ticket is different for every image.

Table 1: Experimental result.

*Numerical values are precision by SNR[dB](p-p/rms) to the correct answer.

PICTURE	Answer	Mode	Expectation
Airplane		15.4	6.6
Balloon		12.0	8.4
Milkdrop		17.6	18.8
Parrots		11.8	12.8

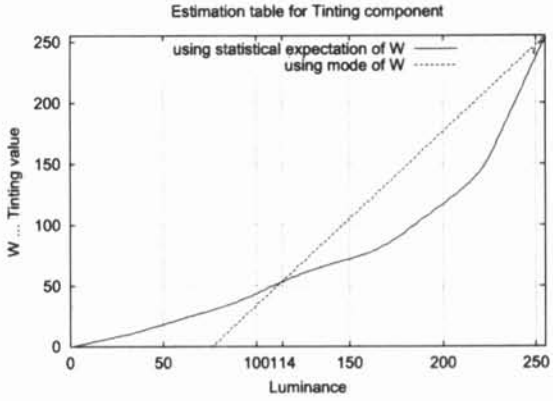


Figure 4: Estimation value in two proposal methods.

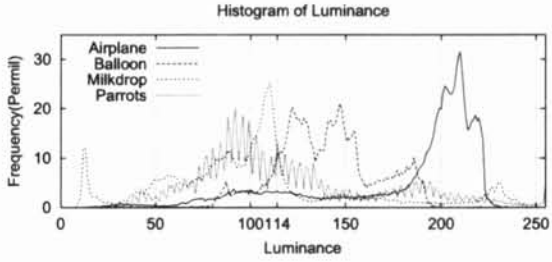


Figure 5: Luminance histogram of images used in experiment.

5 Considerations

In this Section, it consider about the result of Sec.4.

The method of setting an suitable vote ticket is different every image under the decision of uniquely estimation value from a luminance. Therefore, it is considered that the method depends on histogram of gray-scale image. Then, it verify estimation value established with both methods. In Fig.4, the graph of statistical-expectation and Mode of W to y is shown. This graph shows that tinting-order of statistical-expectation and mode crosses at threshold $y = 114$.

In Fig.5, histogram of sample images used in the experiment is shown. From Fig.5 and Table.1, the estimation method for getting high precision is using mode as more pixels of $y \geq 114$, or using statistical-expectation as more pixels of $y \leq 114$.

Proposed method shows that validity changes by pixel's luminance that composes an image under the assumption that original color image containes sufficient tinting-component. If the validity of the estimation method is influenced by luminance, improvement of more estimation precision is expected by changing method as dynamically corresponding to luminance, rather than either one method is used to image. Then, an experiment was made in the same way, changing threshold in the range of $1 \leq y \leq 255$, the table that estimate by mode as over the threshold, and by statistical-expectation as lower the threshold. A result is shown in Fig.6. From Fig.6, it was found out that estimation precision improved about $0.3 - 3.7$[dB] by the dynamic estimation using the threshold $y = 114$ that is changed tinting-order of the estimation value with Fig.4. At rest, the estimation table gotten from this consideration is called "optimized table".

However, the result that got from optimized table does not reach requirement precision except for Milkdrop. Then, it plots the corresponding of luminance tinting value, and it was compared with the estimation value of optimized table about pixel to each image (a) and (b) in Fig.3. A result is shown in Fig.7. From Fig.5 and Fig.7, the image that many pixels' luminance of gray-scale image are distributed in the range beyond $y = 114$, high tinting-value is required more than correspondence of optimized table. And, such as Balloon and Parrots, because an image including many pixels as lower tinting-value than the optimization-table's value (like a pure color and shade color) does not reach a required result, in the premise, the method must examine for estimation whether given gray-scale image has enough tinting-value.

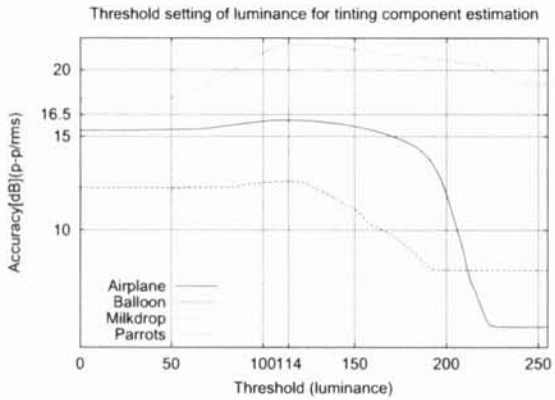


Figure 6: Transition of precision by dynamic threshold changing.

6 Conclusions

In this paper, it was proposed the method for extracting tinting-component from gray-scale image using corresponding relations with luminance and tinting-value.

In this approach, it was proposed how to set up two kinds of vote tickets and it got the result that each extraction precision depended on histogram of luminance. Then, an estimation method was changed dynamically corresponding to luminance. As a result, validity was expected with the gray-scale image that had sufficient tinting-component as original image. And, method of estimation that set the threshold of $y = 114$ extracted in the precision of SNR...12.3−22.4[dB], by using Mode as luminance is under the threshold. To estimate in higher precision, it must investigate adjustment methods corresponding to the image by explaining relations between luminance and tinting-component using more images.

References

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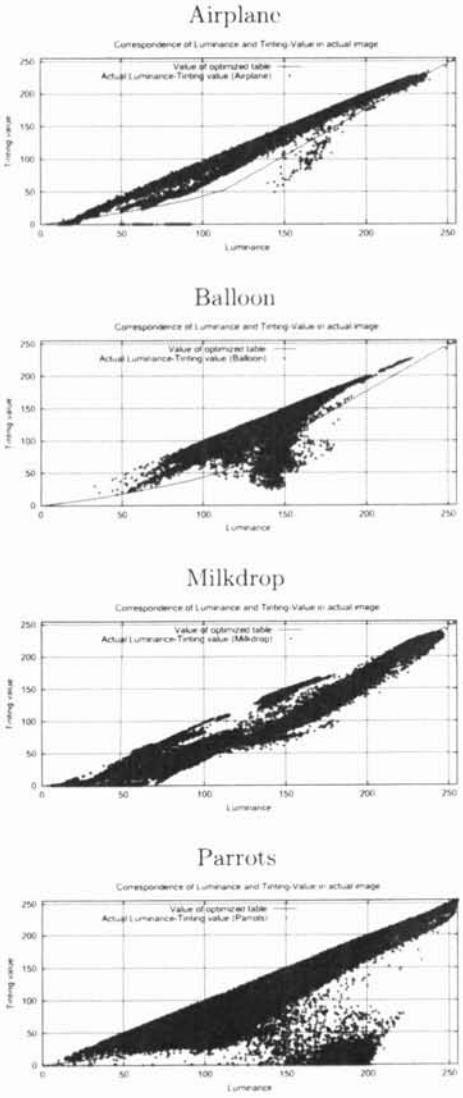

Figure 7: Corresponding relation of luminance and tinting-component in the actual images.

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