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PROPOSED GENERALIZED EQUALIZATION MODEL APPROACH FOR IMAGE ENHANCEMENT

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ABSTRACT
In this paper, we have a tendency to propose a generalized leveling model for image improvement. supported our analysis on the relationships between image bar chart and distinction improvement white reconciliation, we have a tendency to initial establish a generalized leveling model desegregation distinction improvement and white reconciliation into a unified framework of protrusive programming of image bar chart. we have a tendency to show that several image improvement tasks may be accomplished by the projected model exploitation totally different configurations of parameters. With 2 shaping properties of bar chart remodel, specifically distinction gain and nonlinearity, the model parameters for various improvement applications may be optimized. we have a tendency to then derive associate degree best image improvement formula that in theory achieves the most effective joint distinction improvement and white reconciliation result with trading-off between distinction improvement and tonal distortion.

Index Terms: Contrast enhancement, contrast gain, generalized equalization, nonlinearity of transform, tone mapping, white balancing.

INTRODUCTION

WITH the quick advance of technologies and therefore the prevalence of imaging devices, billions of digital pictures square measure being created on a daily basis. Because of undesirable source of illumination, unfavorable weather or failure of the imaging device itself, the contrast and tone of the captured image might not invariably be satisfactory. Therefore, image improvement is usually needed for each the aesthetic and pragmatic functions. In fact, image enhancement algorithms have already been wide applied in imaging devices for tone mapping. as an example, in a typical photographic camera, theCCD or CMOS array receives the photons passing through lens and then the charge levels square measure remodeled to the first image. Usually, the first image is keep in RAW format, with abit-length too huge for traditional displays. Thus tone mapping techniques, e.g. the wide identified gamma correction, are used to transfer the image into an acceptable dynamic vary. a lot of refined tone mapping algorithms were developed through the years, see [2], [8], [12], [29], [33], [34], [43], simply to call afew.Generally, tone mapping algorithms can be classified into two categories by their functionalities throughout the imaging method.

1) White Balancing: Because of the undesirable illuminanceor the physical limitations of cheap imaging sensors, the captured image might carry obvious color bias.1To calibrate the color bias of image, we want to estimate the worth of light source, the matter of that known as constancy [16],[18], [21], [40], [41]. mistreatment suitable physical imaging model, one will get associate approximated brightness, so a lineartransform are often applied to map the first image into an ideal one.

2) Distinction Enhancement: distinction improvement algorithms square measure wide used for the restoration of degraded media, among that international bar chart leveling is that the most popular

choice. Alternative variants includes native bar chart equalization [42] and therefore the abstraction filtering sort of strategies [11], [14], [27],[32], [39], [44]. as an example, in [32] the half filter issued to market the variance of texture thus on enhance the image. In [31], a texture synthesis primarily based formula is proposed for degraded media, like recent photos or films. On the other hand, remodel primarily based strategies additionally exist, e.g. curvelet based algorithm in [35]. In [44], associate adaptative steering regression kernels planned to combine image sharpening with denoising.Despite of the plentiful literature on image improvement, including those representatives listed on top of, 2 challenging problems for image improvement square measure still not resolved. First,howto reach distinction improvement whereas conserving an honest tone.

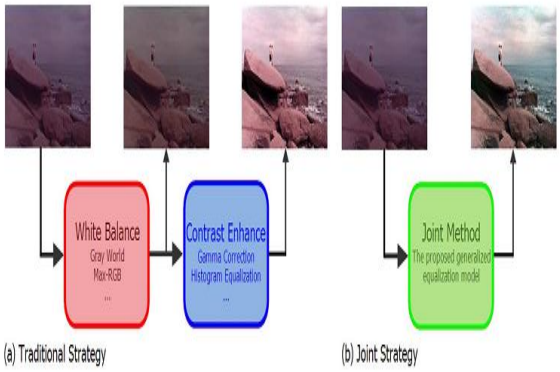

Fig. 1. Figure (a) is the illustration of traditional image enhancement strategy. Figure (b) is the illustration of joint image enhancement strategy.

The contrast and tone of a picture have mutual influence. owing to the difficult interaction, those algorithms merely aiming towards distinction improvement or white balancing cannot offer optimum visual impact. Most, if not all, of current image improvement systems divide white reconciliation and distinction improvement into 2 separate and freelance phases, as Fig.1 (a) shows. This strategy has an evident drawback: although tone has adjusted within the white reconciliation part, distinction improvement might undesirably bias it once more. This trouble has been ascertained in several applications, e.g. the de-hazing algorithms in [26], [37], [38] reach distinction improvement by increasing saturation of the image, however cause tonal distortion income cases. it's simple to imagine that joint white reconciliation and contrast improvement, as Fig. 1(b) shows, may be a a lot of efficient solution towardsoverallquality improvement.Second,how to on paper relate differing kinds of improvement algorithms to every alternative.Inthisaspect,theworkin [30] unifies spatial filtering primarily based improvement strategies, including bi-lateral filter, non-local means that filter, steering regression then on, that has potential applications in image enhancement. However, the procedure complexness of filtering primarily based technique is far more than ancient histogrambasedmethodinmostsituations. In several cases, such as period video police investigation, the bar chart primarily based methods are still being wide used. Taking its significance in practical situations into thought, finding a unified framework of histogram primarily based strategies may be a significant work which will bring more inspirations to the image enhancement downside and facilitate future analysis. though being originated from different applications, each of distinction improvement and white balancing are basically tone manipulation processes. In fact, it's noticed that the majority international algorithms of distinction improvement and white reconciliation square measure supported bar chart remodel. Recently, a unified model for constancy is planned in [40] based on the idea of low-level visual info. However, this unified model doesn't take distinction into thought, so it is proscribed to the applying of white reconciliation. Wu dialect [43]introduced a strict definition of expected context-free distinction and devised a technique known as optimum Contrast-Tone Mapping (OCTM) to resolve distinction improvement downside by maximizing the expected contrast gain subject to associate higher limit on tone distortion. OCTM may be a promising answer for the intensity channel, however it doesn't elucidate the connection between contrast and tone on the color channels. In this paper, we are going to analyze the relationships between image histogram and tone/contrast of image, and establish a generalized leveling model. Wewillproposeaseriesofdefinitionsfor context-free distinction, tone distortion and its nonlinearity, and clarify their relationships in terms of various parametersin the unified model. The generalized leveling model amalgamates histogram-based tone mapping algorithms during a generalized framework of protrusive programming and thus may be a jointstrategy as shown in Fig. 1(b). in depth experimental results show that the planned technique are often wide utilized in a series of improvement applications with promising results.

METHODOLOGY

A. Histogram-Based Analysis on White Balancing

White balancing is a popular image enhancement method, with a critical step of color constancy. Being different from the learning based methods in [15], [16], [18], [21], [41], we focus on a low-level approach to color constancy and establish the relationship between color constancy and the histogram of and image

In the Lambert an surface model, the image is expressed as

$$f_c = \int r(\lambda) l(\lambda) m_c(\lambda) d\lambda \quad (1)$$

Here λ ,is the wavelength of visible light. $r(\lambda)$ is the surface reflectance, $l(\lambda)$ is the light source, (λ) and is the sensitivity of camera in the channel. The goal of color constancy is to estimate the projection of light source on the RGB space. To achieve this goal, many assumptions have been made. For ex-ample, the max-RGB is proposed in [28], which estimates the light source from the maximum responses of the three channels. Another widely used assumption is gray-world hypothesis [4], which assumes that the average reflectance in the scene is Achromatic. Recently, these assumptions are unified in [17], as follows

$$\left(\frac{\int |f(X)|^{\alpha} dx}{\int dx}\right)^{\frac{1}{\alpha}} = Ce \quad (2)$$

From the viewpoint of image histogram, the left side of (2) can be rewritten as

$$\left(\frac{\int |f(X)|^{\alpha} dx}{\int dx}\right)^{\frac{1}{\alpha}} = \begin{pmatrix} (P_r^T)^{\frac{1}{\alpha}} \\ (P)^{\frac{T}{g}} \\ \left((P)^{\frac{T}{b}}\right) \end{pmatrix} \quad (3)$$

Eq. (3) reveals the inter connetion among white balancing and histogram. Given an image, is calculated as

$$e_C(\alpha) = \frac{(P_C^T h_C^{\alpha})^{\frac{1}{\alpha}}}{\sqrt{\sum_{c=r,g,b} (P_C^T h_C^{\alpha})^{\frac{2}{\alpha}}}} \quad (4)$$

As a result, the histogram of white balancing result, denoted as, $\hat{h}_C$ is computed as follows

$$\hat{h}_C = \frac{1}{e_C(\alpha)\sqrt{3}} \hat{h}_C \quad (5)$$

It is obvious that this process is linear. The linearity of the trans-form is the most significant feature of histogram-based white balancing algorithm. In the next subsection, we will show that this linearity is also an important difference between white balancing and contrast enhancement

B.Histogram-Based Analysis on Contrast Enhancement

In [43], the expected context-free contrast of image is defined by

$$C = P_C^T S_C \quad (6)$$

By the definition, the maximum contrast is, which is achieved by a binary black-and-white image; the minimum contrast is zero when the image is a constant. So, the contrast enhancement is achieved by maximizing (6) in [43], as follows

$$\tilde{S}_C = argmax\, P_C^T S_C$$
$$s.t \sum_{i=1}^{K} S_{ci} = L_C \;, S_{CI} \geq d \quad (7)$$

Where the first constraint makes sure that the output image still has a suitable dynamic range and the second constraint denotes the minimum distance between adjacent gray levels as d.

$$h_{ci} - C \sum_{j=n}^{i} P_{Ci} \quad (8)$$

Here C ,is a constant. Eq. (8) also gives a relationship between histogram and the distance between adjacent intensity levels, as following shows

$$\hat{S}_{ci} = \hat{h}_{ci} - \hat{h}_{c,i-1} = \hat{C}_{pci} \quad (9)$$

According to (8), (9), histogram equalization is equivalent to solving following optimization problem

$$\hat{S_C} = argmax \frac{1}{\|P_C^{-1} S_C\|}, \quad (10)$$
$$S.t. \sum_{i=1}^{K} S_{Ci} = L_C, \quad S_{Ci} \geq d$$

The performance of histogram equalization is not optimal in most situations. The essential reason for its limited performance is the questionable assumption that the histogram of ideal image obeys uniform distribution. To get better equalization result, we need to find a better distribution which is a big challenge. Recently, some adaptive histogram equalization methods are pro-posed in [1], [5], [7], [24], [36] but gave neither a clear definition of contrast nor an explicit objective function of contrast enhancement like (7), (10) shows. A common feature of all the enhancement methods mentioned above is that the transform of histogram is non-linear, which is different from white balancing.

The Proposed Model:

The aims of establishing the generalized equalization model include: 1) giving a unified explanation to white balancing problem and contrast enhancement problem; 2) providing an explicit objective function for these two problems and proposing a joint algorithm for them; 3) controlling the performance of the algorithm

by as few parameters as possible. The proposed model is inspired by (7), (10). Although (7),(10) seem to be very different, if we regard the order of and

$$\hat{S}_C = argmax \frac{1}{\left\| P_C^{-\beta} S_C \right\| n}$$

$$S.t. \sum_{i=1}^{K} S_{Ci} = L_C, \quad S_{Ci} \geq d \qquad (11)$$

Both (10) and (7) have interesting relationships with (11)

According to the analysis above, (11) provides a reasonable and unified definition with the objective function of contrast enhancement. We will further take white balancing into the model. Based on (4), (11), we formulate the generalized equalization model mathematically as follows

$$\hat{S_C} = argmax \sum_{c=r,g,b} \left\| P_C^{-1} S_C \right\|_n ,$$

$$S.t \sum_{i=1}^{K} S_{Ci} = \frac{1}{e_c(\alpha)\sqrt{3}} \sum_{i=1}^{K} S_{Ci}, \quad S_{Ci} \geq d \qquad (12)$$

$$G = \frac{P_C^T \hat{S}_C}{P_C^T \hat{S}_C}, NL = \left\| \nabla(\hat{S}_C - \hat{S}_C) \right\| 2 \qquad (13)$$

However, separate nonlinear transform of histograms of three channels may cause tone distortion.

In the next section, we will theoretically prove that the proposed method, with a suitable configuration of parameters, can achieve a best trade-off between contrast enhancement and tone adjustment.

SIMULATION RESULTS

A basic application of the proposed algorithm is image contrast enhancement. In the experiments, the configuration of parameters is $d - 0, \alpha - \infty, n - 2. \beta$ is chosen according to the optimal image enhancement algorithm introduced in the former section. To demonstrate the validity of the proposed algorithm, we design a subjective experiment. In this paper, we analyzed the relationships between image histogram and contrast/tone. We established a generalized equalization model for global image tone mapping. Extensive experimental results suggest that the proposed method has good performances in many typical applications including image contrast enhancement, tone correction, white balancing and post-processing of de-hazed images. In the future, besides global image enhancement, we expect to unify more local image enhancement methods into the model through local image feature analysis.

CONCLUSION

In this paper, we have a tendency to analyzed the relationships between image bar chart and contrast/tone. we have a tendency to established a generalized effort model for world image tone mapping. intensive experimental results recommend that the projected technique has sensible performances in several typical applications together with image distinction sweetening, tone correction, white reconciliation and post-processing of de-hazed pictures. within the future, besides world image sweetening, we have a tendency to expect to unify additional native image sweetening strategies into the model through native image feature analysis.

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