Comparative Study of Generalized Equalization Model for Camera Image Enhancement

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***Abstract*— A generalized equalization model for image enhancement based on analysis on the relationships between image histogram and contrast enhancement white balancing , a generalized equalization model integrating contrast enhancement and white balancing into a unified framework of convex programming of image histogram. Many image enhancement tasks can be accomplished by the model using different configurations of parameters. With two defining properties of histogram transform, namely contrast gain and nonlinearity, the model parameters for different enhancement applications can be optimized. Then derive an optimal image enhancement algorithm that theoretically achieves the best joint contrast enhancement and white balancing result with trading-off between contrast enhancement and tonal distortion.**

Prejudicated and objective experimental results show favorable performances of the proposed method in applications of image enhancement, white balancing and tone correction. Computational complexity of the proposed method is also analyzed.

***Keywords*- Contrast enhancement, contrast gain, generalized Equalization, nonlinearity of transform, tone mapping, white balancing**

I. INTRODUCTION

Prevalence of imaging devices with the fast advance of technologies billions of digital images are being created every day. The contrast and tone of the captured image may not always be satisfactory due to undesirable light source, unfavourable weather or failure of the imaging device, Therefore, aesthetic and pragmatic purposes image enhancement is often required for both the. In fact, image enhancement algorithms have already been used in imaging devices for tone mapping. For example, in a typical digital camera, the CCD or CMOS array receives the photons goes through lens and then the charge levels are transformed to the original image.

Usually, the original image is stored in RAW format, with a bit-length too big for normal displays. So tone mapping techniques, is also known as gamma correction, are used to transfer the image into a suitable dynamic range. Sophisticated tone mapping algorithms was developed through the years [8,9] just to name a few. Generally, tone mapping algorithms can be classified into two types by their functionalities during the imaging process. 1) White Balancing: Because of the the physical limitations of inexpensive imaging sensors,or undesirable illuminance the captured image may carry obvious color bias.1 To improve the color bias of image, we need to estimate the value of light source, the problem of which known as color constancy, Using a suitable physical imaging model, one can get an approximated illuminance, and then a linear transform can be applied to map the original image into an ideal one. 2) Contrast Enhancement: Contrast enhancement algorithms are widely used for the restoration of degraded media, among which global histogram equalization is the most well liked choice. Other variant includes local histogram equalization and the spatial filtering type of methods [10], [11].

II. LITERATURE REVIEW

There are several applications in which image enhancement is required. Several algorithms are developed by different researchers. The algorithms are developed according to types of images and the arena in which image enhancement is required. For image enhancement particular parameter needs to be considered as per requirement. Every algorithm is having its won advantages and limitations. There is no particular measure for the image enhancement, only measure available is human aesthetic approach, hence there is no limitation for the image enhancement. Following are related work done by different researcher for the image enhancement.

Histogram equalization, which aims at information maximization, is widely used in different ways to perform contrast enhancement in images.

DebashisSen.et proposed an automatic exact histogram specification technique and used for global and local contrast enhancement of images. The desired histogram is obtained by first subjecting the image histogram to a modification process and then by maximizing a measure that represents increase in information and decrease in ambiguity. A new method of measuring image contrast based upon local band-limited approach and center-surround retinal receptive field model is also devised in this paper. This method works at multiple scales (frequency bands) and combines the contrast measures obtained at different scales using Lp-norm. In comparison to a few existing methods, the effectiveness of the proposed automatic exact histogram specification technique in enhancing contrasts of images is demonstrated through qualitative analysis and the proposed image contrast measure based quantitative analysis.

The majority of color histogram equalization methods do not yield uniform histogram in gray scale. After converting a color histogram equalized image into gray scale, the contrast of the converted image is worse than that of an 1-D gray scale histogram equalized image [1].

Methodology Use	Advantages	Disadvantages

Histogram equalization	HE can achieve the best performance even though it may not produce the visually pleasing image, and possibly may produce an un-realistic look. However, it is usually desired to have some quantitative measures in proposed method show similar visual quality on many of the images	Author gave neither a clear definition of contrast nor an explicit objective function of contrast enhancement like
Automated method	The method does not require the geometrical information of the input image, and is applicable for both color and gray images.	the de-hazing algorithms achieve contrast enhancement by increasing saturation of the image, but cause tonal distortion
Novel Methodology for contrast enhancement and noise reduction	NLM denoising is adopted for refined smoothing. The tone mapping using optical model was also presented to increase the dynamic range of low-light video.	multiple input images of a scene, which have either different degrees of polarization or different atmospheric conditions is the main drawback of these methods
Three-stage algorithm for haze removal	Most haze removal methods require multiple images or additional prior information. The methods in remove haze using multiple images under different degrees of polarization.	the de-hazing algorithms achieve contrast enhancement by increasing saturation of the image, but cause tonal distortion
Computational photography techniques	This proposed approach allows direct verification of, for instance, image enhancement by human visual models histogram specification. Exact histogram specification allows very precise image normalization, which is of general interest in image processing.	Based on local adaptive filtering
New Automatic method for contrast enhancement gray-level grouping (GLG)	GLG is a general and powerful technique, which can be conveniently applied to a broad variety of low-contrast images and generates satisfactory results.The GLG technique can be conducted with full automation at fast speeds and outperforms conventional contrast enhancement techniques	Auther gave neither a clear definition of contrast nor an explicit objective function of contrast enhancemen
Decomposition techniques	Edge-preserving image smoothing has recently emerged as a valuable tool for a variety of applications in computer graphics and image processing. In particular, in computational photography it is often used to decompose an image into a piecewise smooth base layer and a detail layer	Based on local adaptive filtering many real applications, it's hard to get multi-image in same scene with this condition

Ji-Hee Han, Sejung Yang propose a novel 3-D color histogram equalization method that produces uniform distribution in gray scale histogram by defining a new cumulative probability density function in 3-D color space. Test results with natural and synthetic images are presented to compare and analyze various color histogram equalization algorithms based upon 3-D color histograms. Author also presents theoretical analysis for non-ideal performance of existing methods. Converted image is worse than that of an 1-D gray scale histogram equalized image [2].

TarikArici, SalihDikbas, has presented a general framework based on histogram equalization for image contrast enhancement. In this framework, contrast enhancement is posed as an optimization problem that minimizes a cost function. Histogram equalization isan effective technique for contrast enhancement. However, conventional histogram equalization (HE) usually results in excessive contrast enhancement, which in turn gives the processed image an unnatural look and creates visual artifacts. By introducing specifically designed penalty terms, the level of contrast enhancement can be adjusted; noise robustness, white/black stretching and mean-brightness preservation may easily be incorporated into the optimization. Analytic solutions for some of the important criteria are presented. Finally, a low-complexity algorithm for contrast enhancement is presented, and its performance is demonstrated against a recently proposed method. [3]

Dubok Park1, Minjae Kim2 proposed a novel methodology for contrast enhancement and noise reduction in very noisy data with low dynamic range on images captured by surveillance camera under extremely low light condition. For the initial noise reduction, a motion adaptive temporal filtering based on the Kalman filter is employed. Then, the denoised image is first inverted and subsequently dehazed as a tone mapping to enhance the visibility based on the observation that the inverted low light image presents quite similar characteristics to hazy image. Finally, the remaining noise is removed using the Non-local means (NLM) denoising step. The overall approach essentially transforms very dark images progressively into more visible form and effectively reduces the high intensity noise generated by the tone mapping process. From the experimental results, effectiveness of the proposed method is validated by comparing with the most recent and leading conventional method.

Bad weather, such as fog and haze, can significantly degradethe visibility of a scene. Optically, this is due to thesubstantial presence of particles in the atmosphere that absorband scatter light. In computer vision, the absorptionand scattering processes are commonly modeled by a linear combination of the direct attenuation and the airlight. Based on this model, a few methods have been proposed, and most of them require multiple input images of a scene ,which have either different degrees of polarization or different atmospheric conditions. This requirement is the main drawback of these methods, since in many situations, it is difficult to be fulfilled [4].

To resolve the problem, J.-P. Tarel and N. Hautiere introduce an automated method that only requires a single input image .This method is based on two basic observations: first, images with enhanced visibility (or clear-day images) have more contrast than images plagued by bad weather; second, air light whose variation mainly depends on the distance of objects to the viewer, tends to be smooth. Relying on these two observations, we develop a cost function in the framework of Markov random fields, which can be efficiently optimized by various techniques, such as graph-cuts or belief propagation. The method does not require the geometrical information of the input image, and is applicable for both colour and gray images.

Mages of outdoor scenes are usually degraded under bad weather conditions, which results in a hazy image. To date, most haze removal methods based on a single image have ignored the effects of sensor blur and noise [5].

Xia Lan1, Liangpei Zhang2, a three-stage algorithm for haze removal, considering sensor blur and noise, is proposed. In the first stage, Author preprocesses the degraded image and eliminates the blur/noise interference to estimate the hazy image. In the second stage, we estimate the transmission and atmospheric light by the dark channel prior method. In the third stage, a regularized method is proposed to recover the underlying image. Experimental results with both simulated and real data demonstrate that the proposed algorithm is effective, based on both the visual effect and quantitative assessment.

Contrast enhancement has an important role in image processing applications. Conventional contrast enhancement techniques either often fail to produce satisfactory results for a broad variety of low-contrast images, or cannot be automatically applied to different images, because their parameters must be specified manually to produce a satisfactory result for a given image [6].

Z. Chen, B. Abidi, D. Page, and M. Abid introduce a new automatic method for contrast enhancement is described. The basic procedure is to first group the histogram components of a low-contrast image into a proper number of bins according to a selected criterion, then redistribute these bins uniformly over the gray scale, and finally ungroup the previously grouped gray-levels. Accordingly, this new technique is named gray-level grouping (GLG). GLG not only produces results superior to conventional contrast enhancement techniques, but is also fully automatic in most circumstances, and is applicable to a broad variety of images. An extension of GLG, selective GLG (SGLG), and its variations is discussed in the paper. SGLG selectively groups and ungroups histogram components to achieve specific application purposes, such as eliminating background noise, enhancing a specific segment of the histogram.

While in the continuous case, statistical models of histogram equalization/specification would yield exact results, their discrete counterparts fail. This is due to the fact that the cumulative distribution functions one deals with are not exactly invertible. Otherwise stated, exact histogram specification for discrete images is an ill-posed problem. Invertible cumulative distribution functions are obtained by translating the problem in a K–dimensional space and further inducing a strict ordering among image pixels [7].

D. Coltuc, P. Bolon and J.-M. Chassery the proposed ordering refines the natural one. Experimental results and statistical models of the induced ordering are presented and several applications are discussed: image enhancement, normalization, watermarking, etc.

Many recent computational photography techniques decompose an image into a piecewise smooth base layer, containing large scale variations in intensity, and a residual detail layer capturing the smaller scale details in the image. In many of these applications, it is important to control the spatial scale of the extracted details, and it is often desirable to manipulate details at multiple scales, while avoiding visual artifacts [8].

Z. Farbman, R. Fattal, D. Lischinski introduces a new way to construct edge-preserving multi-scale image decompositions. Author shows that current base detail decomposition techniques, based on the bilateral filter, are limited in their ability to extract detail at arbitrary scales. Instead, Author advocates the use of an alternative edge-preserving smoothing operator, based on the weighted least squares optimization framework, which is particularly well suited for progressive coarsening of images and for multi-scale detail extraction. After describing this operator, Author shows how to use it to construct edge-preserving multi-scale decompositions, and compare it to the bilateral filter, as well as to other schemes. Finally, Author demonstrates the effectiveness of our edge-preserving decompositions in the context of LDR and HDR tone mapping, detail enhancement, and other applications [9].

J. K. et al., ―Deep introduce a novel system for browsing, enhancing ,and manipulating casual outdoor photographs by combining them with already existing geo referenced digital terrain and urban models. A simple interactive registration process is used to align a photograph with such a model. Once the photograph and the model have been registered, an abundance of information, such as depth ,texture, and GIS data, becomes immediately available to our system .This information, in turn, enables a variety of operations, ranging from dehazing and relighting the photograph, to novel view synthesis, and overlaying with geographic information. Author describes the implementation of a number of these applications and discusses possible extensions. Author's results show that augmenting photographs with already available 3D models of the world supports a wide variety of new ways for us to experience and interact with our every day snapshots [10].

R. Fattal, ―Single image dehazing presents a new method for estimating the optical transmission in hazy scenes given a single input image. Based on this estimation, the scattered light is eliminated to increase scene visibility and recover haze-free scene contrasts. In this new approach we formulate a refined image formation model that accounts for surface shading in addition to the transmission function. This allows us to resolve ambiguities in the data by searching for a solution in which the resulting shading and transmission functions are locally statistically uncorrelated. A similar principle is used to estimate the color of the haze. Results demonstrate the new method abilities to remove the haze layer as well as provide a reliable transmission estimate which can be used for additional applications such as image refocusing and novel view synthesis [11].

III. System Algorithm

1. Input Camera image **f** = (fr, fg ,fb)T
2. Separate image in three intensity matrices R,G,B
3. Find out histogram of three intensity matrices {hc,pc}c=r,g,b .
4. Calculate intensity levels of three matrices.
5. Calculate average distance between adjacent intensity levels.
6. Find out area of concentration of pixel intensities.
7. If the pixels are concentrated in particular region of intensity, spread out the pixel concentration throughout the available intensity levels.
8. Apply the adjustment parameter to spread out the pixel concentration throughout the available intensity levels.
9. Check the quality of image by combining three intensity matrices R, G, B.
10. Apply the white balancing parameter to the image.
11. Tune the adjustment parameter by small fractional value and go to 8 for 1st iteration only.
12. Check the quality of image before and after fine tuning, if the quality of image after tuning is better go to 11 else 13.
13. Consider last but one image as enhanced image.

In the above algorithm decision maker is the user only. User can decide the quality of image by his visual aesthetic approach.

IV. Conclusions

In this paper, we analyzed the relationships between image histogram and contrast/tone. We recognized a generalized equalization model for global image tone mapping. Extensive experimental results suggest that the determined method has good performances in many typical applications including post-processing of de-hazed images image contrast enhancement, tone correction, white balancing. In the future, besides global image enhancement, we expect to combine more local image enhancement methods into the model through local image feature analysis.

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