Color Image Enhancement Using JND Transform

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Abstract- *In this paper, we propose perceptually optimized enhancement of contrast and color in images using just-noticeable-difference (JND) transform and color constancy. We adopt JND transform to get JND map that represents the perceptual response of the human visual system (HVS). We utilize color constancy to estimate the light source color and be robust to color bias. First, we use a perceptual generalized equalization model for the optimization of both color and contrast based on color constancy and contrast enhancement, i.e. base image. Second, we generate JND map based on HVS response model from foreground and background luminance, called JND transform. Next, we update the JND map based on Weber's law to boost perceptual response. Finally, we perform inverse JND transform from the base image and its JND map to produce the enhanced image highly correlated with the human visual perception. Experimental results show that the proposed method achieves good performance in contrast enhancement, color reproduction, and detail enhancement.*

Keywords- Contrast enhancement, color constancy, image enhancement, just-noticeable difference,JND transform, HVS response model

I. INTRODUCTION

With the fast development of the digital imaging technology,billions of digital photos are created by smart phones,cameras, scanners and computers every day. During the capturing process, their contrast is often degraded by undesirable light source, bad weathers and failure of the imaging device itself. Moreover, old images contain historical events among the years, but are of low perceptual contrast and color bias. Thus, contrast enhancement and color constancy are required for better visual perception and interpretation of the scene in many cases. In general, contrast enhancement methods are classified into two groups from the viewpoint of methodology. The first group is spatial filtering-based methods. By preserving the low-frequency component with amplifying the high-frequency part, they achieve local contrast enhancement and make the details obvious [1]_[4].The second group is histogram-based methods. Compared with filtering-based methods, histogram-based ones have been more widely used in global contrast enhancement due to the low computational complexity. Histogram equalization (HE) is the most popular and classical one. Based on HE, many variant methods have been proposed [5]_[8]. Their main issue is how to preserve a good tone while achieving contrast enhancement. OCTM [8] solved the contrast enhancement problem by maximizing the contrast gain subject to an upper limit on tone distortion. It achieved outstanding performance in contrast enhancement of the intensity channel. However, it has a limit to consider the relationship between contrast and tone on three color channels.Thus, Xu et al. [9] proposed a generalized equalization model (GEM) that integrated contrast enhancement and white balancing into a unified framework based on the of HVS response model that simulates HVS perception.Color constancy estimates the scene illuminant and then utilizes it to map the color-biased image to the canonical image under white light source. First, we perform perceptual GEM to adjust the image tone while preventing overenhancement.Perceptual GEM effectively selects the pixels of high contrast and sensitivity in human eyes and constructs the image histogram based on Weber's law [10] and JND model, i.e. luminance adaptation that indicates the minimum threshold perceived by HVS [11]. Second, we perform JND transform to obtain JND map from foreground and background luminance, and update it using the ratio between the enhanced and original base grayscale images. Next, we obtain the final gray scale image with fine details by inverse JND transform. Finally, we produce the perceptually optimized enhancement result by color restoration from the final grayscale image. Fig. 1 illustrates the entire framework of the proposed method. Compared with exiting methods,main contributions of the proposed method are as follows:_ We propose JND transform for contrast enhancement to effectively extract detail information with much attention by HVS._ We provide JND-based perceptual GEM to effectively allocate a dynamic range while preventing over-enhancement.The rest of this paper is organized as follows: In Section 2,we illustrate the related work of our work. In Section 3,we introduce the human visual perception model. The details of the proposed method are described in section 4.In Section 5, we provide experimental results and their corresponding analysis, while we draw conclusions of this paper in Section 6.relationship between image histogram and contrast enhancement/white balancing. GEM achieved good performance in enhancing both contrast and color while preserving the image tone. However, GEM often allocates a large dynamic range in a dark smooth region with over-enhancement as well as produces unnatural-looking results with tone discontinuity.In this paper, we propose perceptually optimized enhancement of contrast and color in images using JND transform and color constancy. We perform JND transform to estimate JND map that represents perceptual response of HVS from an image. That is, JND map is mainly composed

II. LITERATURE SURVEY

Wenjun Zhang et al(2014) states that the ideal IQA metric should be effective and efficient, yet most of existing FR IQA methods cannot reach these two targets simultaneously. Under the supposition that the human visual perception to image quality depends on salient local distortion and global quality degradation, we introduce a novel effective and efficient local-tuned-global (LTG) model induced IQA metric. Extensive experiments are conducted on five publicly available subject-rated color image quality databases, including LIVE, TID2008, CSIQ, IVC and TID2013, to evaluate and compare our algorithm with classical and state-of-the-art FR IQA approaches.On the one hand, many studies were devoted to the subjective IQA by recording real human ratings under the condition of specific image distortion types, viewing environments and inexperienced viewers. Several famous subject-rated image quality databases are LIVE, TID2008, CSIQ, and IVC. Very lately, Ponomarenko et al. released the TID2013, which is up to now the largest image quality database consisting of totally 3000 distorted images. It is easy to find the subjective assessment is usually a time-consuming, laborious and costly task, and this makes it in most cases serve as the testing tool for the objective assessment.

Jinjian Wu et al(2016) proposed that the difference (JND) reveals the visibility of our human visual system (HVS), below which changes cannot be perceived by the human. Though dozens of JND estimation models have been introduced during the past decade, how to accurately estimate the JND thresholds for different content regions (e.g., edge and texture region) is still an open problem. Research on cognitive science indicates that the HVS is adaptive to extract the visual regularities from an input scene for content perception and understanding. Thus, we analyze the effect of content regularity on visual sensitivity, and suggest that the visual regularity is another important factor that determines the JND threshold. According to the orientation distributions of local regions, the content regularities are firstly calculated. Then, by considering the effect from content regularity, luminance adaptation, and contrast masking, a novel JND model is proposed.We focus on pixel-domain JND estimation. Chou and Li analyzed the masking effect from the background luminance and edge height, and proposed an early pixel-domain JND model. All of these pixel-domain models improve the estimation accuracy of JND to some extent. However, there are still a large gap between these existing JND models and the human perception.

Hongteng Xu et al(2014) described the relationship between image histogram and contrast enhancement/white balancing, we first establish a generalized equalization modelintegrating contrast enhancement and white balancing into a unifiedframework of convex programming of image histogram. Weshow that many image enhancement tasks can be accomplishedby the proposed model using different configurations of parameters.With two defining properties of histogram transform, namelycontrast gain and nonlinearity, the model parameters for differentenhancement applications can be optimized. We then derive an optimalimage enhancement algorithm that theoretically achieves thebest joint contrast enhancement and white balancing result withtrading-off between contrast enhancement and tonal distortion. Subjective and objective experimental results show favorable performancesof the proposed algorithm in applications of image enhancement, white balancing and tone correction.In fact, image enhancement algorithms have already been widely applied in imaging devices for tone mapping. For example, in a typical digital camera, the CCD or CMOS array receives the photons passing through lens and then the charge levels are transformed to the original image. the original image is stored in RAW format, with a bit-length too big for normal displays. So tone mapping techniques, e.g. the widely known gamma correction, are used to transfer the image into a suitable dynamic range.

Xiaolin Wu et al(2011) explained that in a fundamental departure from the current practice of histogram equalization for contrast enhancement, the proposed approach maximizes expected contrast gain subject to an upper limit on tone distortion and optionally to other constraints that suppress artifacts. The underlying contrast-tone optimization problem can be solved efficiently by linear programming. This new constrained optimization approach for image enhancement is general, and the user can add and fine tune the constraints to achieve desired visual effects. In most image and video applications it is human viewers that make the ultimate judgment of visual quality. They typically associate high image contrast with good image quality. Indeed, a noticeable progress in image display and generation (both acquisition and synthetic rendering) technologies is the increase of dynamic range and associated image enhancement techniques various causes such as poor illumination conditions, low quality inexpensive imaging sensors, user operation errors, media deterioration (e.g., old faded prints and films), etc. For improved human interpretation of image semantics and higher perceptual quality, contrast enhancement is often performed and it has been an active research topic since early days of digital image processing, consumer electronics and computer vision. Contrast enhancement techniques can be classified into two approaches: context-sensitive (point-wise operators) and context-free (point operators). In context-sensitive approach the contrast is defined in terms of the rate of change in intensity between neighboring pixels. The contrast is increased by directly altering the local waveform on a pixel by pixel basis.

Yi-Fei Pu et al(2010) explained the structures and parameters of each mask respectively on the direction of negative x-coordinate, positive x-coordinate, negative y-coordinate, positive y-coordinate, left downward diagonal, left upward diagonal, right downward diagonal, and right upward diagonal. Moreover, by theoretical and experimental analyzing, we demonstrate the second is the best performance fractional differential mask of the proposed six ones. Finally, we discuss further the capability of multiscale fractional differential masks for texture enhancement. Experiments show that, for rich-grained digital image, the capability of nonlinearly enhancing complex texture details in smooth area by fractional differential-based approach appears obvious better than by traditional intergral-based algorithms.Texture enhancement is an important issue in many areas like pattern recognition, image restoration, medical imaging processing, robotics, interpretation of image data, and remote sensing. Despite a family of techniques has been greatly developed over the last couple of decades, there are only a few reliable methods for texture-enhancing are presented. Multiresolution techniques seem to be attractive approaches for many applications.

ChulLee et al(2009) found that an optimized brightness-compensated contrast enhancement (BCCE) algorithm for transmissive liquid crystal displays (LCDs) is proposed in this paper. We first develop a global contrast enhancement scheme to compensate for the reduced brightness when the backlight of an LCD device is dimmed for power reduction. We also derive a distortion model to describe the information loss due to the brightness compensation. Then, we formulate an objective function that consists of the contrast enhancement term and the distortion term. By minimizing the objective function, we maximize the backlight-scaled image contrast, subject to the constraint on the distortion. Simulation results show that the proposed BCCE algorithm provides high-quality images, even when the backlight intensity is reduced by up to 50-70% to save power.

CHEN Qing-li et al(2010) explained that to improve the image contrast, a 2-D isotropic fractional differential algorithm for contrast enhancement is constructed, and its structure and parameters on 8 directions are presented. This nonlinear filter algorithm is implemented on various low-contrast digital images and the contrast enhancement of image is controlled by fractional order. The capability of fractional differential mask for contrast enhancement is discussed. The Experiments and analysis show that the proposed method has excellent feedback for enhancing contrast of dark images, it enhances edge information effectively and reveals more detailed information than HE and SSR method for low-contrast images. Contrast enhancement is one of the most important issues of image processing and analysis, and plays an important role in image processing, pattern recognition, computer vision, and etc. It is believed that contrast enhancement is a crucial step to sharpen the low contrast image. Image enhancement is employed to transform an image on the basis of the psychophysical characteristics of human visual system. Many algorithms for achieving contrast enhancement have been developed. Histogram 21 Equalization (HE) is the most commonly used method due to its simplicity and comparatively better performance on almost all types of images.

III. CONCULUSION

We have proposed perceptually optimized enhancement of contrast and colour in images using JND transform and colour constancy. We have performed JND transform to get a JND map that represents the perceptual response of HVS. We have conducted perceptual GEM to adjust the image tone while preventing over-enhancement. We have combined perceptual GEM with JND transform to achieve contrast enhancement, colour reproduction and detail enhancement in images. Experimental results demonstrate that the proposed method successfully enhances low contrast images with colour bias and dark tone. Our future work includes investigating noise reduction in contrast enhancement of images.

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