Fast Algorithm Image Enhancement Based on the Luminance, Contrast and Multi Scale Retinex Characteristics of Human Visual System

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Abstract – *For Image Processing Applications, the Image Enhancement place a crucial role. Based on different sets of criteria, many enhancement algorithms have been proposed. One of the image enhancement algorithm is multi scale enhancement algorithm, is capable of independently providing contrast enhancement, tonal rendition, dynamic range compression and accurate edge preservation in a controlled manner. A multi-scale image enhancement algorithm based on a new parametric contrast measure is presented. The formulation of the contrast measure can be adapted for any multi-resolution decomposition scheme. The multi scale enhancement is exemplified using the Laplacian pyramid, discrete wavelet transform, stationary wavelet transform and dual tree complex wavelet transform. The advantages of the multi scale image enhancement algorithm are 1)integration of both the luminance and contrast, 2)extension of non linear mapping scheme, 3)adjusting overall brightness, 4)dynamic range compression. For better performance the Fast algorithm is used based on multi scale retinex. The Fast algorithm is computationally complex due to non linear color conversion. The Fast algorithm for calculations of RGB color components uses linear color dependencies from the V-components of HSV model. The RGB values of an image pixel are computed by multiplying a new brightness with the brightness to RGB component values ratio of the original image. It allows to reduce image processing time on 30-75% depending on the image size. In addition, the usage of Haar wavelet transform for low frequency is used. It is faster in 2-2.8 times than multi scale.*

Key Words: HSV-

1. INTRODUCTION

The aim of image enhancement is to modify images in such a way that the visual content contained in the image is improved for human or machine perception.

Enhancement algorithms can broadly be classified as either direct or indirect enhancement procedures. Indirect enhancement algorithms enhance images without explicitly defining and measuring image contrast. Such algorithms include histogram equalization (HE) and its variants. Basic pixel transformations, and contrast stretching operations. These approaches do not directly measure image contrast direct enhancement algorithms have been developed based on the fact that the human visual system (HVS) is adapted to extract local structural information. Direct enhancement approaches, thus, quantitatively define a contrast measure in either a spatial or transform domain, and achieve enhancement by magnifying the measured contrast. The most basic of these algorithms is the well known un-sharp masking algorithm and its multi-scale extensions. The direct enhancement algorithms which have been described are largely contrast enhancement procedures, in that their aim is to generally increase the measured contrast.

Retinex algorithms using the HSV color model and MSRCR have low processing speed. For HSV models, this is due to non-linear color conversion, and for MSRCR it is connected with processing of three color components. For a number of spheres of application of image enhancement methods based on Retinex technology processing speed is very important, for example in video surveillance and during a large medical images set processing..

2. HUMAN VISUAL SYSTEM PHENOMENA

The breadth of the discussion is by no means an all encompassing explanation of the inner workings of the HVS and its many subtleties. Here, key concepts are established which will be pertinent in developing HVS-inspired tools for image enhancement. Namely, the HVS can be regarded as a multi-scale device, and analyzing images at their many scales therefore emulates the early stages of image formation by the HVS. Moreover, the contrast which is perceived by the HVS is both a function of the local background luminance and local activity. These characteristics will later be integrated into the proposed multi-scale contrast measures and transforms, which are ultimately utilized to achieve direct image enhancement.

2.1 Multi Scale Characteristics of HVS

The eye functions as a transducer, focusing light from objects in a field of view and converting them to electrical signals processed by the brain. Incident light is refracted through the cornea and passes through the pupil. The lens further reflects this light, ultimately projecting an image onto the retina. The flexibility of the lens changes the focal length of the eye so that objects of interests are in focus. The retina can be perceived as an array of neurons assembled in a way that they form a set of apertures whose receptive fields vary widely in size. These neurons are photo-receptors which accept incoming photons which have been refracted onto them and synapse onto cells which ultimately cause electrical signals to reach the visual cortex.

2.2 Luminance Masking

The HVS perceives relative luminance changes for a large range of background intensity values [19]. The degree to which the HVS is sensitive to relative, and not absolute, luminance differences varies with background illumination. This response has been characterized by a piecewise function which divides contrast sensitivity into 4 regions, namely the dark, Devries- Rose, Weber, and saturation regions, and defines the dependency of perceived contrast on the background illumination for each region the contrast is not expressed as a ratio of a difference and an average, but the difference of logarithms is consistent with the LM phenomena in that the contrast measure is less sensitive to case of the higher base luminance. While the single and multi-scale Retinex (MSR) algorithms themselves do not use a direct framework for image enhancement, it is observed that the image can be expressed in terms of the center-surround contrast.

2.1 Contrast Masking

The HVS is sensitive not only to relative changes in luminance, but also to relative changes in contrast. This CM phenomena of HVS is one in which the visibility of a certain stimulus is reduced due to the presence of another one. This is to say that if a certain pattern is placed near no other stimuli, a given amount of contrast is perceived by the human eye, and when this pattern is surrounded or superimposed by other stimuli, the perceived contrast of the pattern decreases. An example of this spatial masking effect is that the HVS is more sensitive to additive white noise in smooth areas of an image than in regions of high contrast.

3. DIRECT MULTI SCALE CONTRAST ENHANCEMENT

Each transform will generate an approximation coefficient sub-band *y(n)* and a set of oriented detail coefficient sub-bands at level of decomposition *n*. The transform can be recursively applied to successive approximation coefficient sub-bands yielding an *N* level decomposition. for practical purposes, the transform can generally be characterized by their bases, the number of detail coefficient sub-bands at each analysis stage, the orientation of these detail coefficient sub-bands, and the relative dimension of approximation and detail coefficient sub-bands of the same scale, and the relative dimension of approximation coefficient sub-bands at successive scales.

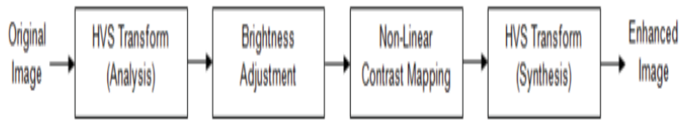

Fig 3.1: Block Diagram of Proposed Enhanced Algorithm

4. RETINEX BASED IMAGE ENHANCEMENT

The Retinex belong to the class of center-surround functions, thus each output value of the function is determined by the corresponding input value (center) and its neighborhood (surround).

4.2 Single Scale Retinex

Single-Scale Retinex, is the most basic method for Retinex algorithm. In SSR algorithm, the illumination is estimated by convolving a Gaussian filter with an input image, and the resulting scene reflectance *RSSR* is obtained in log-scale. The mathematical computation can be described as

$$R_{SSR_i}(x,y,\sigma) = \log\left(I_i(x,y)\right) - \log\left(I_i(x,y) * G(x,y,\sigma)\right)$$

where), (*yxI i* is the value of the x and y coordinates for the *i*-th color channel of the RGB model,),, (*σyxG*is a Gaussian, the symbol * denotes convolution.

4.2 Multi Scale Retinex

Because of the trade-of between dynamic range compression and color rendition, the choice of the right scale σ for the Gaussian filter is crucial in Single-Scale Retinex. The Multi-Scale Retinex output is defined as a weighted sum of several SSRs outputs. Mathematically the generalized MSR form for one spectral band can be represented as follows

$$R_{MSR}(x,y,\boldsymbol{\sigma}) = \sum_{k=1}^{n} w_k R_{SSR_k}(x,y,\sigma_k)$$

where *n* is the number of scales, **σ** = {*σ*1, *σ*2, ... *σn*) is the vector of the blurring coefficients, *wk* is the weight associated with the k-th scale where *w*1+*w*2+...+*wn*=1, RSSRkis the k-th component of the scale.

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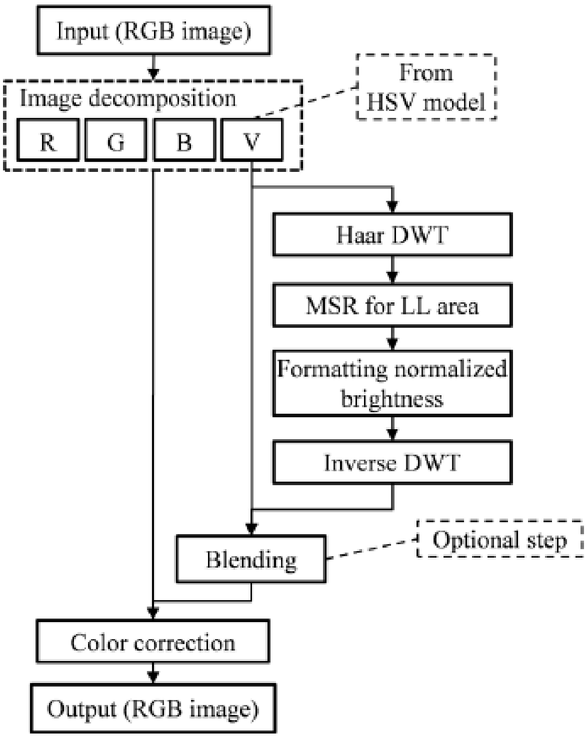

Fig 4.1: Scheme of Exciting Method

4.3 Improvement of Multi Scale Retinex

Multi-Scale Retinex has its advantages, but there are some problems especially when the source image violates the "gray world" assumption regionally or entirely. It may cause unpredictive color distortion because of the "gray world" violation. The "gray world" assumption states that given an image with sufficient amount of color variations, the average value of the red, green and blue components of the image should average out to a common gray value. One way to solve this problem is the use a color restoration function9. The following calculation formula can be used,

$$R_{MSRCR_i}(x,y,\sigma) = \beta \log\left(\alpha \frac{I_i(x,y)}{\sum_{l=1}^{3} I_l(x,y)} \right) R_{MSR_i}(x,y,\sigma)$$

where $Ii(x,y)$ is the value of the x and y coordinates for the i-th color channel of the RGB model; β is the gain constant; α is a parameter controlling the strength of nonlinearity.

5. RESULTS

The effectiveness of the presented image enhancement algorithms is validated through computer simulations. The Figures illustrates that the proposed enhancement algorithm can indeed be carried out in any of the HVS-based multi-scale transform domains which have been developed thus far. While the enhancement results in each transform domain have their own subtle difference, the enhancement procedure can effectively enhance the image both locally and global in each of the transform domains. The proposed method is also compared to existing indirect and direct enhancement approaches.

Fig (a) Fig(b)

Fig(c)

Fig 5.1 Original Images

Fig (a) Fig (b)

Fig (c)

Fig 5.2 Results of Exciting Method

 

Fig (a) Fig (b)

Fig (c)

Fig 5.3 Results of Proposed Method

CONCLUSION

Different methods to improve the performance of the MSR in HSV color space are proposed Thus proposed algorithm of image enhancement based on Multi-scale Retinex, allows to get a result equals to MSR in HSV color model but with less processing time. The new image enhancement algorithm is capable of adjusting the appropriate brightness level of the image directly, and used a non-linearly mapping to contrast coefficients at each scale. This mapping was capable of providing both dynamic range compression and contrast enhancement, and in conjunction with the brightness control, the resulting image enhancement algorithm was able to achieve local and global enhancements simultaneously within a direct enhancement framework

REFERENCES

1) K. Panetta, E. Wharton, and S. Agaian, "Human visual system based image enhancement and logarithmic contrast measure," IEEE Trans. Syst., Man, Cybern. B, Cybern., vol. 38, no. 1, pp. 174–188, Feb. 2008.

2) J. Tang, E. Peli, and S. Acton, "Image enhancement using a contrast measure in the compressed domain," IEEE Signal Process. Lett., vol. 10, no. 10, pp. 289–292, Oct. 2003.

3) W. Selesnick, R. G. Baraniuk, and N. G. Kingsbury, "The dual-tree complex wavelet transform," IEEE Signal Process. Mag., vol. 22, no. 6, pp. 123–141, Nov. 2005.

4) X. Liu, J. Tang, S. Xiong, and Z. Feng, "A multiscale contrast enhancement algorithm for breast cancer detection using Laplacian Pyramid," in Proc. Int. Conf. Inf. Autom., Jun. 2009, pp. 1167–1171.

5) E. Wharton, K. Panetta, and S. Agaian, "Human visual system based multi-histogram equalization for non-uniform illumination and shadow correction," in Proc. IEEE Int. Conf., vol. 1. Apr. 2007, pp. 729–732.

6) Xue M, Ji Y, Yuyan Z, Weiwei L, Jiugen Z. Video image dehazing algorithm based on Multi-Scale Retinex with color restoration. Proceeding of the InternationalConference on Smart Grid a Electrical Automation (ICSGEA), Zhangjiajie; 2016. p. 195-200

7) Sun B, Tao W, Chen W, Li H, Li J, Guo W. Luminance based MSR for color image enhancement. 2008 Congress on Image and Signal Processing. Sanya, China; 2008. p. 358-362.