Combined Contrast Stretching and Homomorphic Normalised Filtering for Color Image Enhancement

Megha Rajan, Radhakrishnan B, Raji P G

P.G Scholar, Dept of CSE, BMCE, Kollam, Kerala, India.

megharajan592@gmail.com,

Abstract— Image enhancement area in image processing provides a wide range of techniques which can be used for enhancing images quality as well as the natural look of the image. This paper proposes the enhancement techniques which enhances the image and protects the image from loosing the natural look. To improve image under varying lighting conditions, contrast normalization along with homomorphic filtering based illumination normalization method is proposed in this paper. In this work the effect of illumination is effectively normalized by the homomorphic filtering and the contrast is normalized by contrast stretching. The resulted image is not only enhances illumination effect but also preserves edges and details that will facilitate the further processing task.

Keywords— Image enhancement, image processing, illumination, contrast normalization, homomorphic filtering, illumination normalization, contrast stretching,

INTRODUCTION

In image enhancement, when different techniques are used the chance of degradation of natural look and the contrast are higher. The enhancement will work well on grey scale images but in case of color images the enhancement sometimes results in over enhancement or contrast degradation. The contrast enhancement is a widely using image enhancement technique. The contrast in an image is the difference between the color and the brightness that makes an object in the scene distinguishable. The brightness is the feature of vision that defines how much light the source reflects makes the source appears to be reflecting the light. But the brightness and the lightness are two different aspects. Their are direct enhancement techniques [1],[2] and indirect enhancement techniques [3] [4]. Direct methods define a contrast measure and try to improve it. Indirect methods, on the other hand, improve the contrast through exploiting the under-utilized regions of the dynamic range without defining a specific contrast term [5].

The contrast can also be defined as the amount of color or the grey scale differentiation value that exists between various images. Many image enhancement algorithms, such as the Retinex based algorithms [6], the unsharp masking algorithms [7], the histogram equalization (HE) algorithms [8], etc., have been proposed. Part of the algorithms focus on detail enhancement, but usually result in unnatural looks, such as light source confusion and artifacts. Hence, some others attempt to reduce over-enhancement at the cost of the details [9].

Retinex theory assumes that the sensations of color have a strong correlation with reflectance, and the amount of visible light reaching observers depends on the product of reflectance and illumination [10]. Most Retinex-based algorithms extract the reflectance as the enhanced result by removing the illumination, and therefore they can enhance the details obviously [6], [11]. But it is impossible to exactly remove the illumination for the scenes of unsmooth depth. Some center/surround algorithms take the local convolution of the lightness instead of the illumination without considering the limit of the reflectance [6], [7]. In fact, the reflectance should be within 0 and 1, which means the surface cannot reflect more light than that it receives. Moreover, it is unreasonable to simply remove the illumination which is essential to represent the ambience [12]. The bright-pass filter which is used to preserve the natural look in the non-illumination images also restricts the reflectance to 0 and 1. This will give the output as grey scale image. But the complexity of implementing the bright-pass filter is more compared with the other enhancement algorithms [9].

The unsharped masking algorithms decompose the image into the low frequency and high frequency terms and then processing it independently. The classical unsharp masking algorithm can be described by the equation: $v = y + \gamma(x - y)$ where x is the input image, y is the result of a linear low-pass filter, and the gain $\gamma(\gamma > 0)$ is a real scaling factor. The signal $d = x - y$ is usually amplified $(\gamma > 1)$ to increase the sharpness. However, the signal contains 1) details of the image, 2) noise, and 3) over-shoots and under-shoots in areas of sharp edges due to the smoothing of edges. While the enhancement of noise is clearly undesirable, the enhancement of the under-shoot and over-shoot creates the visually unpleasant halo effect. Ideally, the algorithm should only enhance the image details. This requires that the filter is not sensitive to noise and does not smooth sharp edges [7].

HE technique is simple but widely-used for image enhancement. Since conventional HE algorithms may result in over enhancement, many algorithms with restrictions, such as brightness preservation [8], [13] and contrast limitation [14], have been proposed. Brightness preservation is useful in the applications that need to preserve the intensity. However, for non-uniform illumination images, brightness preservation is disadvantageous to detail enhancement in the areas of inappropriate intensity, such as the dark areas. Contrast limited algorithms restrain over-enhancement by redistributing the histogram in such a way that its height does not go beyond the clip limit. But, it is not easy to fix the clip limit for the images of seriously non-uniform illumination, in which the histograms of different areas are quite different [9].

In the image enhancement using contrast enhancement Quantitative evaluation is not trivial, as there do not exist any universally accepted measure of contrast or ideally enhanced images as references. Measures of dispersion (local and global) such as variance, standard deviation and entropy have been used to evaluate contrast enhancement. Quantitative evaluation of contrast enhancement should be based upon appropriate measurement of contrast at all image pixels. Any reasonable measure of contrast should be at least crudely tuned according to the retinal visual system and such a measure would then probably be more credible and universally acceptable [15].

In the naturalness preserved image enhancement algorithm the three major issues are discussed such as the naturalness preservation, the intensity decomposition and the illumination effect. Firstly the lightness order error measure for the naturalness preservation is proposed to assess enhanced images. Secondly, the image is decomposed through the brightpass filter, which insures the reflectance is restricted in the rage of 0 and 1. Thirdly, a bi-log transformation is proposed to process the illumination so that the illumination will not flood details due to spatial variation while the lightness order is preserved. But when implementing the brightpass filter, the complexity of the process increases and it is time consuming [9].

Therefore, we propose a method which enhances the image by decomposing the image into reflectance and illumination and then transforming the image for final result.

METHODOLOGY

In this paper we propose the image enhancement technique which can be used in color images. This method uses mainly three methods. The first method is the contrast stretching, which stretches the intensity values which improves the contrast. Then the resulted image is processed with homomorphic filtering. The image can be expressed as the product of illumination and reflectance. In this paper the homomorphic filtering is used, where the image is decomposed to reflectance and illumination. Illumination and reflectance are not separable, but their approximate location in the frequency domain may be located. Then the resulted image is processed by normalizing the image. For the images with the varying lighting conditions the contrast adjustment is necessary for preserving the edges as well as the details contained in the image. Normalization is a process that changes the range of pixel intensity values. It simultaneously normalizes the brightness across an image and increases the contrast. In this the normalization is done in the basis of the illumination component of an image.

PROPOSED WORK

For the enhancement of the image and the preservation of the edges and the details of the image, the image is subjected to contrast stretching, then the output is transformed using the transformation functions and then the output is normalized to get the final enhanced output image.

In this method the image is first decomposed into the RGB components. Where, output of the decomposition will be three different grey scale images. Then the contrast normalization of the image is done to these three images. Then the contrast normalization is done by the contrast stretching technique.

Then the image is decomposed to the illumination and reflectance component. Where the illumination is the light absorbed by the object and the measure of light get illuminated. The reflectance is the amount of light that is reflected from the object. The illumination and reflectance of an image is described as the pixel intensity, where the amount of light reflected from the object in the scene, is the product of the illumination and the reflectance of the objects presented in the scene, which can be expressed as:

$$I(x,y) = il(x,y) * R(x,y) \tag{1}$$

In this paper the decomposition of the image is done by homomorphic filtering. The basic theory of the homomorphic filtering starts with taking the natural log of the model as described in the equation (2). Since illumination and reflectance combine multiplicatively, the components are made additive by taking the logarithm of the image intensity, so that these multiplicative components of the image can be separated linearly in the frequency domain.

$$\ln\big(I(x,y)\big) = \ln\big(il(x,y)\big) + \ln(R(x,y)) \tag{2}$$

then the result is transformed using the Fourier transformation function

$$\mathrm{F}\big(\ln\big(I(x,y)\big)\big) = F_I(x,y) = F\big(\ln\big(il(x,y)\big)\big) + F(\ln(R(x,y))) \tag{3}$$

Where the equation (3) can be replaced as

$$F_I(x,y) = F_{il}(x,y) + F_r(x,y) \tag{4}$$

Then apply the filter function H(x,y)

$$E(x,y) = F_I(x,y)H(x,y) = F_{il}(x,y)H(x,y) + F_r(x,y)H(x,y) \tag{5}$$

Then the inverse fourier transformation is applied

$$F^{-1}E(x,y) = \ F^{-1}(F_{il}(x,y)H(x,y)) + F^{-1}(F_r(x,y)H(x,y)) \tag{6}$$

Then the enhanced result I^1, can be obtained by taking the exponential function of the result

$$I^1 = e^{E(x,y)} \tag{7}$$

The transformation of the image is done on the basis of illumination transformation on reflectance component of an image. The illumination normalization is done as the next step to the resulted image obtained after applying equation (7) on the image. The dynamic range expansion in various applications is usually to bring the image into a specified range which is more familiar to the senses. The normalization also works in the same perspective that it transforms the n dimensional grey scale image into a new image. As the output of the image decomposition is the grey scale image, normalization can be applied to the three components that is the RGB components of the image. Then the three components of the image after normalization is subjected to synthesizing to form a single color image. The proposed system is explained briefly in the below figure.

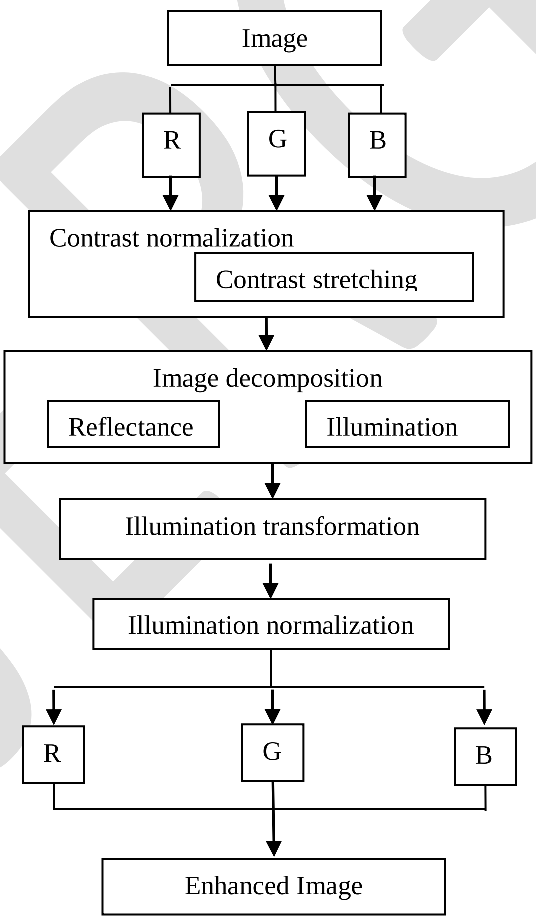

Fig 1 Overview of the proposed system

CONCLUSION

This paper proposes the methodology that will enhance the image without loosing its natural look. For different images the lighting conditions may vary according to the scene. To enhance the images under the varying lighting conditions the contrast normalization along with the homomorphic filtering is effective and easy way to obtain the result. As the filtering is based on the illumination, the contrast is stretched and the resulted image will enhance the illumination effect as well as preserves the edges and the details of the image. So that the resulted images obtained by the proposed method are visually pleasing and preserves the natural look of the image.

REFERENCES:

[1] H.-D. Cheng and H. J. Xu, "A novel fuzzy logic approach to contrast enhancement," pattern Recognit., vol. 33, no. 5, pp. 809–819, May 2000.

[2] A. Beghdadi and A. L. Négrate, "Contrast enhancement technique based on local detection of edges," Comput. Vis, Graph., Image Process., vol. 46, no. 2, pp. 162–174, May 1989.

[3] R. Sherrier and G. Johnson, "Regionally adaptive histogram equalization of the chest," IEEE Trans. Med. Imag., vol. MI-6, no. 1, pp. 1–7, Jan. 1987.

[4] A. Polesel, G. Ramponi, and V. Mathews, "Image enhancement via adaptive unsharp masking," IEEE Trans. Image Process., vol. 9, no. 3, pp. 505–510, Mar. 2000.

[5] T. Arici, S. Dikbas, and Y. Altunbasak, "A histogram modification framework and its Application for image contrast enhancement," IEEE Trans. Image Process., vol. 18, no. 9, pp. 1921–1935, Sep. 2009.

[6] D. J. Jobson, Z. Rahman, and G. A. Woodell, "Properties and performance of a center/surround retinex," IEEE Trans. Image Process., vol. 6, no. 3, pp. 451–462, Mar. 1996.

[7] G. Deng, "A generalized unsharp masking algorithm," IEEE Trans. Image Process., vol. 20, no. 5, pp. 1249–1261, May 2011.

[8] C. Wang and Z. Ye, "Brightness preserving histogram equalization with maximum entropy: A variational perspective," IEEE Trans. Consum. Electron., vol. 51, no. 4, pp. 1326–1334, Nov. 2005.

[9] Shuhang Wang, Jin Zheng, Hai-Miao Hu, and Bo Li, "Naturalness preserved enhancement algorithm for non-uniform illumination images", IEEE Trans. Image Process., vol. 22, no. 9, pp.3538-3548, Sep. 2013.

[10] M. Bertalmio, V. Caselles, and E. Provenzi, "Issues about retinex theory and contrast enhancement," Int. J. Comput. Vis., vol. 83, no. 1, pp. 101–119, 2009.

[11] D. J. Jobson, Z. Rahman, and G. A. Woodell, "A multi-scale retinex for bridging the gap between color images and the human observation of scenes," IEEE Trans. Image Process., vol. 6, no. 7, pp. 965–976, Jul. 1997.

[12] B. Li, S. Wang, and Y. Geng, "Image enhancement based on Retinex and lightness decomposition," in Proc. IEEE Int. Conf. Image Process., Sep. 2011, pp. 3417–3420.

[13] H. Ibrahim and N. Kong, "Brightness preserving dynamic histogram equalization for image contrast enhancement," IEEE Trans. Consum. Electron., vol. 53, no. 4, pp. 1752–1758, Nov. 2007.

[14] A. M. Reza, "Realization of the contrast limited adaptive histogram equalization (CLAHE) for real-time image enhancement," J. VLSI Signal Process., vol. 38, no. 1, pp. 35–44, 2004.

[15] D. Sen and S. K. Pal, "Automatic exact histogram specification for contrast enhancement and visual system based quantitative evaluation," IEEE Trans. Image Process., vol. 20, no. 5, pp. 1211–1220, May 2011