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IMAGE ENHANCEMENT USING FAST HIGH-DIMENSIONAL KERNEL FILTERING THROUGH HISTOGRAM EQUALIZATION

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Abstract

Image enhancement is a key factor in the area of image analysis, feature extraction and any further higher level processing of the image. The quality of the processed image cannot be scarified at any cause and contrast is always appreciated in higher level processing. The purpose of image contrast enhancement is to improve the features of an image. Contrast Enhancement plays a vital role in different kinds of images such as Natural, Medical and Microscopic for quality improvement. However, contrast enhancement may not be necessary for all images as processing of high contrast images costs time and computations. Hence, an automatic algorithm is required to classify the images as low contrast and high contrast to improve the quality of the images. In this paper we are applying Histogram Equalization on color images with Different Color Space like RGB ,HSV and Histogram Specification on gray Scale images and color images.

1. Introduction

Digital image processing is a technique used to analyse the required particular part of the images which comprises two levels of processing. Lowlevel methods usually use very little knowledge about content of images. These methods often include image compression, pre-processing methods for noise filtering, edge extraction and image sharpening. High-level processing is based on knowledge, goals and plans of how to achieve those goals, and artificial intelligence methods are widely applicable (Milan Sonka et al 1993). Low-level processing helps to enhance high-level processing. These image processing techniques help to transfer the image from one form to another form. The input image may undergo a wide range of enhancement processes such as filters, contrast stretching, brightness, colour adjustments, etc., to extract the required information from the image. In the case of poor visual images poor contrast and brightness images make more difficult to review the particular part of the image. 2 Enhancement of images provides more flexibility in handling the images. Enhancement techniques are widely used in real time applications such as consumer electronics, medical image and disease analysis, cloud image analysis, space image analysis, defect detection in the processing industries, biometric security authentications and various other applications.

Better image quality is preferred for the analysis of any image. In many forms of imaging devices, the quality of images is often affected by a variety of factors including distortion and noise produced due to lack of experience in taking images by the operator and adverse environmental conditions, such as unfavourable illumination. As a result, the captured images may not reveal sufficient details of the true scene and, even worse which may contain artifacts such as washed-out and unnatural appearances. In these cases, Contrast Enhancement (CE) techniques are useful to produce more visually pleasing and informative images.

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2. Literature survey

Contrast Enhancement is one of the most acceptable methods for enhancement of medical images. Different contrast enhancement methods like Contrast Stretching, Histogram Equalization, AHE, CLAHE are already available. Histogram equalization is one of the well-known method that is useful in various applications of image processing. Histogram equalization flats the density distribution and enhances the contrast of the image as HE has effect on stretching dynamic range. Even though, it has high performance while enhancing the contrasts of a given image, it is rarely employed because the direct use of the histogram improves brightness of the input image and visual quality but introduces artifacts. An adaptive HE technique where a cumulation function was used by generating the gray level mapping from local histogram to improve the contrast enhancement of the image was proposed by Alex Stark (2000). Sundaram et al (2011) presented an early detection method of breast cancer in the mammogram images. The Histogram Modified Local Contrast Enhancement (HM-LCE) was introduced to adjust the level of contrast enhancement, which gave the resultant image a high contrast. It incorporates a two stage processing i.e both histogram modifications as an optimization technique and a local contrast enhancement technique. A thermo dynamical model to define local information content to measure local contrast was given by Mario Ferraro & Giuseppe Boccignone (2004). This technique showed spatial structure across multiple scales to complete local contrast map which helped in better enhancement. Qi Shan et al (2010) introduced a new tone mapping operator that performed local linear adjustments on small overlapping windows over the entire input image which helped to preserve the image structure even in challenging high dynamic range image.

3. PROPOSED METHOD

RGB conversion: generally histogram equalization methods are applied on black & white and gray scale images. Inorder to apply the histogram equalization for colour images, If I be the colour input image,it is divided into Red, green and blue colour channel as follows:

R=I(:,:,1)

G= I(:,:,2)

B=I(:,:,3)

The Red, green and blue colour channels are separately applied to both dynamic stretching and RGB-to-HSI operations.

Dynamic stretching:

The proposed Dynamic stretching enhancement method performs histogram equalization based on a local modified contrast-stretching manipulation and replaces each original intensity value of the input image. The new intensity is assigned to each pixel according to an adaptive transfer function that is designed on the basis of the statistics of the input images. The details of this algorithm are given below.

First assumed that the input image is I, the output image is X and the size is as same as the size of input image the intensity range of the input image is defined as 'Range' which can be calculated as (1).

$$Range = I_{max-}I_{min}$$

where Imax and Imin are the maximum and minimum intensity values of the input image. The new intensity is assigned to each pixel according to equation (3.2) ie.,

$$X_k = I_k - \sigma_k \text{ , if } I_k = I_{min}$$
$$= I_k + \sigma_k \text{ , if } I_k = I_{max}$$
$$= f_k \quad , \quad \text{else}$$
$$\text{Where } ,f_k = I_{min} + \frac{r_k|I_k - I_{min}|}{|I_{max} - I_{min}|},$$

σ_k is the standard deviation of input image.

$$r_k = w - \sqrt{(range - w)^2}$$

w' lies between 0.01 to 0.02.Using the above formulae, each pixel value is replaced. By this way, the image noise can be suppressed while enhancing image features. After Dynamic stretching operation on each RGB color space, the RGB image is converted into HSI color space image.

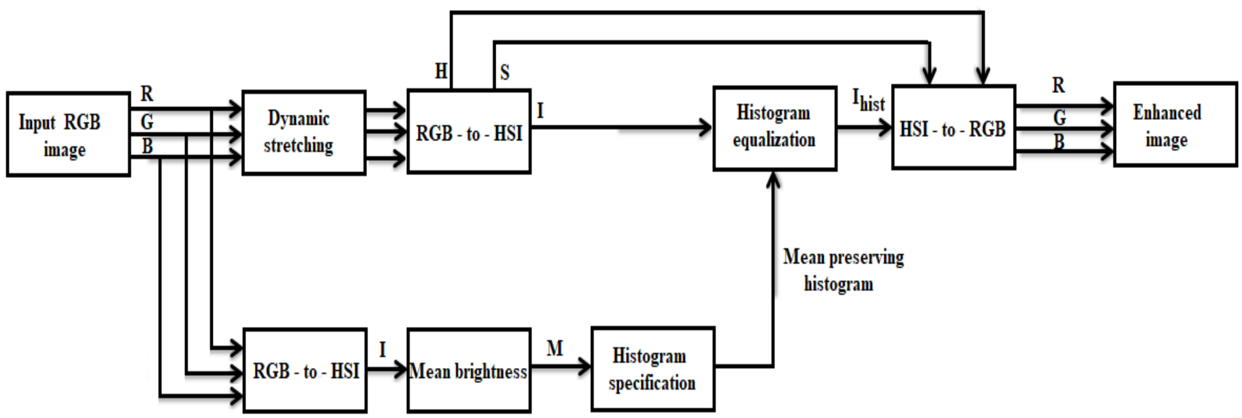

Fig. 1 Proposed block diagram for brightness preserving histogram equalization approach

RGB to HSI CONVERSION:

In order to process color image in RGB color space using this scheme, image first must be transformed to hue, saturation and intensity (HSI) color space. Here Brightness is a synonym of intensity. Hue represents the impression related to the dominant wavelength of the color stimulus Saturation shows the relative color purity (amount of white light in the color). Hue and Saturation taken together are called the chromaticity coordinates (polar system). In this method we apply the Histogram Equalization on V component on HSI color space.

The colour space conversion will be as follows:

$$H=\cos^{-1}\left(\frac{(R-G)+(R-B)}{2\sqrt{(R-G)^2+(R-B)(G-B)}}\right)$$

$$S = 1 - \frac{3}{(R+G+B)}[\min(R,G,B)]$$

$$I = \frac{1}{3}[R+G+B]$$

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The supplementary branch of HSI image (otherthan dynamic stretching) is applied to mean brightness operation on intensity image.

MEAN BRIGHTNESS: For sure, the changes in dynamic range, and also histogram equalization process will alter the mean brightness of the image. Therefore, this step in this method is to normalize the output image M to the input mean brightness. The output mean M brightness value, which is the average intensity of all pixels that construct the input intensity image. So the mean brightness of the resultant image will lie between the input mean and the middle gray level.

Histogram equalization: In histogram equalization (also known as histogram flattening), the goal is to improve contrast in images that might be either blurry or have a background and foreground that are either both bright or both dark.Low contrast images typically have histograms that are concentrated within a tight range of values. Histogram equalization can improve the contrast in these images by spreading out the histogram so that the intensity values are distributed uniformly over a larger intensity range. Ideally, the histogram of the output image will be perfectly flat.The process for histogram equalization is as follows:

Step 1: Obtain the histogram.

h (i) = $\boldsymbol{p_i}$

= (number of pixel of intensity level i / total number of pixels)

= normalized histogram = probability density function PDF

Step 2: Obtain the cumulative distribution function CDF.

The cumulative distribution function H(j) is defined as the probability H of a randomly selected pixel taking one of the intensity values from 0 through j (inclusive). Therefore, given our normalized histogram h(i) from above, we have the following formula:

$$CDF = H(j) = \sum_{i=0}^{j} h(i) \qquad \text{where } j = 0,1,\ldots\ldots\ldots..254,255$$

Step 3: Calculate the transformation T to map the old intensity values to new intensity values.

Let K represent the total number of possible intensity values (e.g. 256). j is the old intensity value, and T(j) is the new intensity

$$T(j) = \text{floor}\,((k-1)*CDF_j)$$

Step 4: Given the new mappings of intensity values, we can use a lookup table to transform each pixel in the input image to a new intensity.The result of this transformation is a new histogram which corresponds to a new output image.

Histogram Specification

Histogram Specification is an extension to the basic histogram equalization technique. In basic histogram equalization technique, what we are trying to achieve is that the output histogram should follow the uniform pdf. But, for histogram specification, we want the output histogram tofollow according to the histogram we specify. To achieve this, we first histogram equalize the input image, then the pdf of this resulting equalized image will be matched to the pdf of the desired histogram [3].

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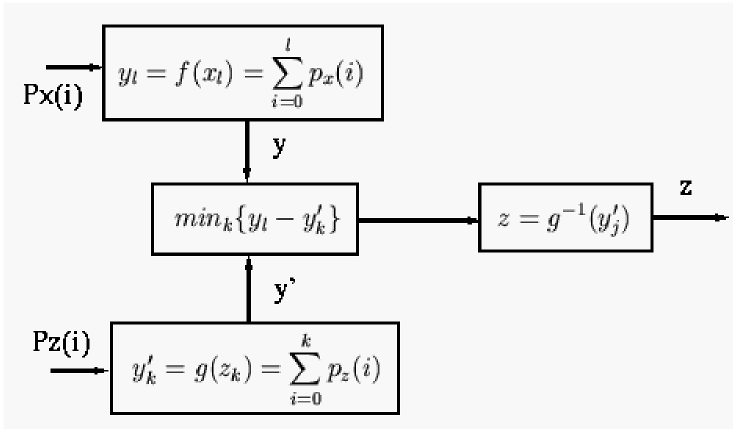

Fig 2: Histogram Specification

Here are the specific steps of the algorithm:

Step 1: Find histogram of input image h_x , and find its cumulative h_x, the histogram equalization mapping function:

$$H_x[j] = \sum_{i=0}^{j} h_x\,[i]$$

Step 2: Specify the desired histogramh_z, and find its cumulative h_z, the histogram equalization mapping function:

$$H_z[j] = \sum_{i=0}^{j} h_z\,[i]$$

Step 3: Relate the two mapping above to build a lookup table for the overall mapping. Specifically, for each input level i, find an output level j so that $H_z[j]$ best matches

$$|H_x[i] - H_z[j]| = min_k|H_x[i] - H_z[k]|$$

and then we setup a lookup entry .Look up [i] = j

HSI to RGB:

Finally modified Intensity image from histogram equalization is concatenated with the Hue and saturation image. And they are converted back to the original RGB color space format as decribed below:

- RG sector $(0 \leq H < 120)$

  B = I (1-S)

  R = I $\left[1 + \frac{SCOSH}{\cos\,(60-H)}\right]$

  G =1- (R+B)

- GB sector $(120 \leq H < 240)$

  R = I (1-S)

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$$G = I\left[1 + \frac{SCOS\,(H-120)}{\cos(\,60-(H-120))}\right]$$

B =1- (R+B)

- BR sector $(240 \leq H < 360)$

G = I (1-S)

$$B = I\left[1 + \frac{S\,COS\,(H-240)}{\cos(\,60-(H-240))}\right]$$

R =1- (G +B)

Finally concatenated RGB image gives the contrast enhanced color image.

4. SIMULATION RESULTS:

Test case 1: low light image 1

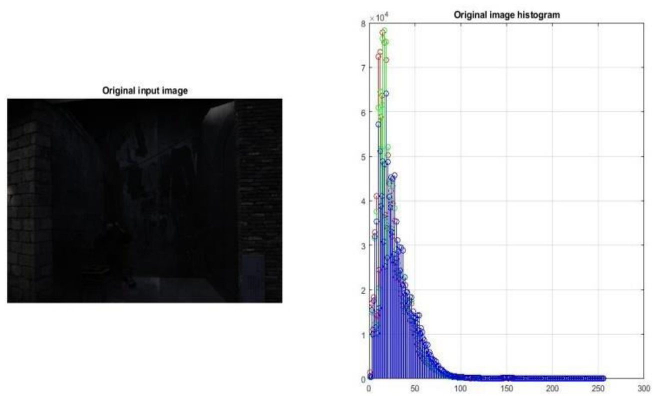

Fig 1: Input image

Fig 2: results for lowlight image

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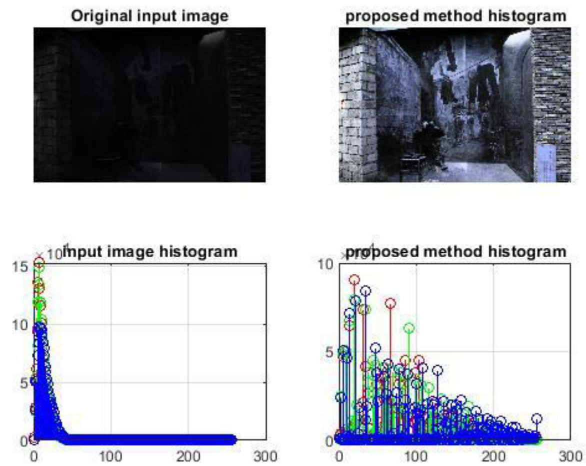

Fig 3: results and histogram levels for proposed methods

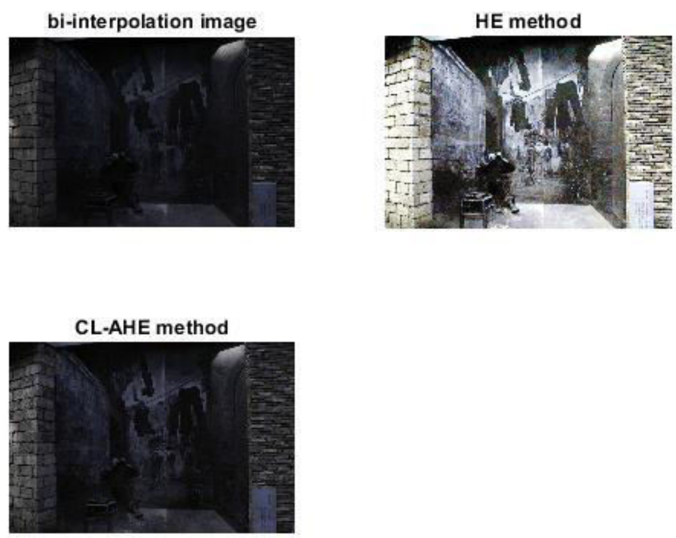

Fig 4: results for existing methods

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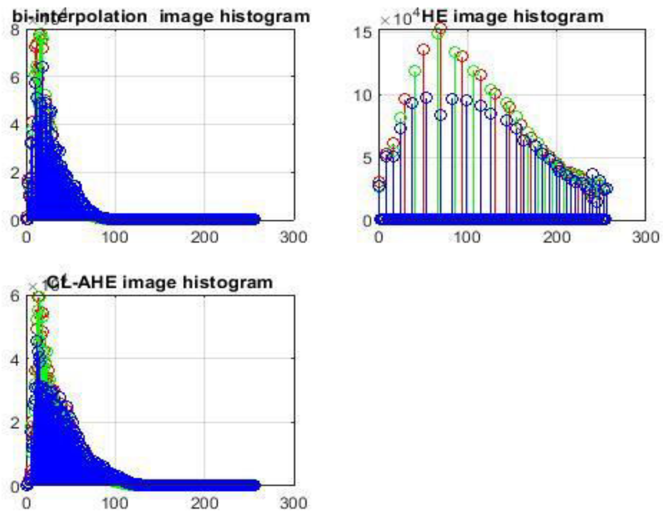

Fig 5: histogram levels for existing methods

PSNR of Bi-linear interpolation is 10.08 dB
PSNR of HE method is 16.46 dB
PSNR of CL-HE method is 17.58 dB
PSNR of existing method is 56.90 dB
PSNR of proposed method is 71.28 dB
SSIM of Bi-linear interpolation is 0.72
SSIM of HE method is 0.66
SSIM of CL-HE method is 0.78
SSIM of existing method is 0.85
SSIM of proposed method is 0.83

Fig 6 Parametric comparison

5. CONCLUSION

In this article, methods that we applied balances the requirements of both appearance enhancement and being faithful to the original appearance of an image has been proposed and applied to the enhancement of full color images. Results have shown the effectiveness of our algorithm in improving the contrast and colourfulness of the original images. In this paper, we have shown that we can get better image from histogram specification with our own proposed histogram equalization on color image gives us better results.

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