Image Enhancement with the Application of Local and Global Enhancement Methods for Dark Images

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***Abstract*—Image enhancement is a technique used to get a better quality of an image in terms of its clarity, brightness and to give the human eye comfortable to look at. There are different types of techniques to give good quality of an image. Global image contrast enhancement is one of the most commonly used technique to enhance the quality of an image, but it has some disadvantages with the fact that it does not consider the local details of an image. Local details of an image are very important while analyzing an image, which is that of the scientific study of an image like the image taken from planetary bodies, satellite image and medical images. Local details of an image are very important for diagnosing a particular ailment. When either local contrast enhancement or global contrast enhancement is used alone, there is loss of brightness of the image. In order to address and reduce this discrepancy of individual enhancement methods, a new method is presented in this paper, that uses both local and global enhancement methods on the same image. First, the image is locally enhanced and the output is again processed by the global enhancement method thereby giving a properly enhanced image without losing the brightness of the image. This enhancement method is simulated in MATLAB and results are verified on the parameters of image quality.**

***Keywords*—Global contrast stretching, image enhancement, image sharpening, local contrast stretching, unsharp masking,.**

I. Introduction

The human visual perception of an image can be greatly affected by the contrast of an image. Contrast is defined as the difference in the pixel intensity value of a particular pixel to its neighboring pixels. If the difference in the intensity is more, then we can say that the contrast is more of that image. The more contrast gives better clarity of an image in terms of local details. The details in the local information of an image are very important if the image is of medical or astronomical applications for analyzing and extracting the information of that image and proper diagnosing of the ailments based upon the image of a cell. So with the advancement of science and technology, especially in the field of signal processing, the quality of an image can be enhanced so that it gives clear and detailed information about the image [1]. There are various techniques for enhancing the image quality and many techniques have been proposed to address various aspects of an image over the years.

Contrast stretching is one of the various techniques that is used for image enhancement. There are two types of contrast stretching methods namely global and local methods. The global method of contrast stretching is very common in image enhancement, it gives a satisfactorily good quality of an image for viewing purpose but it lacks the local details of the image as it mainly focused on the global details of the image that is overall information of the image and neglects the local details of an image. The local method enhances the local details of the image, that is the slight variation of the image is addressed and provides the minute details of the image. It lacks from the overall information of the image pixel enhancement. In this combined algorithm, one's discrepancy is addressed by another. The minute details of the image are addressed by the local method which is not addressed in the global method. Many researchers have developed techniques for enhancing of an image. The equalization of the histogram of an image for enhancement of the image is very common and effective. Histogram equalization based contrast enhancement techniques was presented in [2] for preserving brightness. In [3], each and every peak of the histogram is equalized separately. It is a technique of spatial domain of an image. Spatial domain means processing of image is done directly on the image pixel, not on the other transformed domain. One single technique cannot be used as a universal technique that can be applied to all types of images. One technique may give a very good result to a specific type of image but may not give to another type.

Various contrast stretching methods have been proposed to enhance the image of leukemia, a medical image in [4]. When a dark stretch is performed, the bright portions of the image or the bright pixels are more brightened. A better way to address such problem is to enhance the dark regions by keeping the bright regions untouched [5], these have shown the effects of various contrast stretching techniques like global stretching, local contrast stretching, partial contrast stretching etc. The problems of a blurred image, which is caused by the motion of the object while taking the image, and how to avoid is presented in [6]. It also used local edge detection to deblur the original image. In [7], the effect of application of both global and local contrast enhancement is studied on gray scale image and only the brightness parameter of the image has been observed. This method is being used in this paper on the dark color image and image enhancement parameters like mean and measure of enhancement factor is calculated and the output image is compared with the existing image enhancement techniques.

This paper is organized as follows: In Section II, Image enhancement techniques are presented. Section III describes the methodology of the algorithm. In Section IV, the implementation of proposed method and results are explained and section V concludes the paper.

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II. Image Enhancement Techniques

Image enhancement techniques have been widely used to get a good quality of an image for the human interpretation. Image enhancement techniques are broadly classified as local image enhancement and global image enhancement.

A. Local Enhancement of the Image

The local enhancement is employed to get the minute details of an image. It enhances the local details in terms of the gradient of the image which gives useful information to the analyzer of the image. It addresses those pixels which would be ignored by the global method. The local enhancement method employed here is unsharp masking [8]. In this method the image is sharpened by subtracting an unsharp image, that is a blurred or smoothed from the original image, so the name unsharp masking is derived. In this method the following steps are involved:
1. Blurring of the image.
2. Subtracting the blurred image from the original image to make the mask.
3. Adding the mask to the original image.

If the blurred image is denoted as b (i,j) and the image as p (i,j) then the mask m (i,j) is given according to equation (1).

$$m(i,j) = p(i,j) - b(i,j) \tag{1}$$

The weighted portion of the mask is added to the original image to get the sharpened image s (i,j) given by equation (2).

$$s(i,j) = p(i,j) + w * m(i,j) \tag{2}$$

where 'w' is the weight, generally greater than zero. When the weight is equal to 1, it is the unsharp masking and when greater than 1 then it is called high boost filtering. This sharpened image is given as input to the global contrast enhancement process for further improvement in the image quality or to improve the visual quality of the image.

B. Global Enhancement of the Image

The global enhancement of the image is used to increase the contrast of the image. In this process each pixel of the image is adjusted so that it gives a better visualization of the image. In spatial contrast enhancement, the operation is performed directly on the pixel. The pixels are arranged in such a way that it is distributed throughout the range of desired intensity level. Global contrast stretching method is used as global method of enhancing the image. There are many global techniques like histogram equalization (HE), contrast limited adaptive histogram equalization and many other transformation methods like discrete cosine transform (DCT), discrete shearlet transform (DST), adaptive inverse hyperbolic tangent function transformation, etc. Among these, HE is the one used widely as global method [8]. Any of the method can be used to enhance the image globally. In all the global methods they did not consider the local details of the image and look for the global information of the image. So we first apply the local enhancement in order to verify the algorithm, the simple HE is used. It is not mandatory to use only this method, different

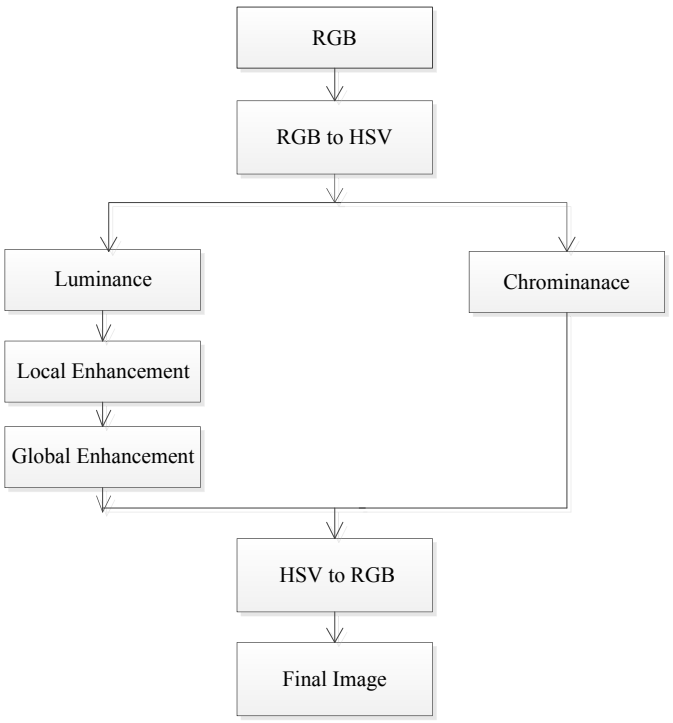


Fig. 1. Flow graph of the proposed image enhancement.

methods can be used to improve the image quality. For the discrete image, the probabilities of the pixel value is taken in HE. To take the probabilities, first the corresponding number of pixels should have particular pixel intensity value, it is calculated and divided by the total number of the pixels present in the image. The probability of occurrence of pixel intensity level 'k' in the digital image is stated by equation (3).

$$p(r_{\mathrm{k}}) = \frac{n_{\mathrm{k}}}{N * M} \tag{3}$$

Where N*M is the total number of pixels in the image and n_k is the total number of pixels having intensity level "k". The pixels are transformed according to the following transformation equation in discrete form [8].

$$t_k = L(r_k) = (G-1)\sum_{i=0}^{k} p(r_i) = \frac{G-1}{N*M}\sum_{i=0}^{k} n_i \tag{4}$$

where 'G' is the highest intensity level or value, L (r_k) is the transform function and k = 0, 1, 2, 3, ..., G-1. So the output image pixel is obtained by mapping each input pixel r_i to the new transformed value t_k. The processed output value may have fractional value so a rounding function to the nearest integer value is needed. While doing so some of the image pixels may go to the new value and some of the intensity pixel values may not be present in the transformed image.

III. Proposed Image Enhancement Method

Fig. 1 shows the proposed method to be incorporated in order to get a good quality image by combining both local enhancement and global enhancement of a color image. It mainly consists of the following four steps.

Step 1: Get the color image and convert it into hue, saturation and value (HSV) color space and take the luminance of that image.
Step 2: Apply the local enhancement method to enhance the local details of image.
Step 3: The local output is again given as global input and perform global image enhancement.
Step 4: Recombine the components and reconvert it back to color image.

In this method first an image is taken and converted from the red green and blue (RGB) color space to the HSV color space. From the HSV colour space, the V component or the luminance component is taken to apply the algorithm. In order to enhance the local gradients or the local details, an existing local enhancement method has been used. Here the unsharp masking is used as local details enhancement method. As the name suggests it uses the blurred image to make the mask and enhances the local details in the form of edge sharpening. The sharpened image is used as the input to the global enhancement method. The global enhancement method uses one of the global contrast stretching methods. At first a color image to be enhanced is taken and it is converted to the HSV color space. From that color space the luminance portion is taken. The enhancement in the hue and saturation is not done. The image enhancement is performed only in the luminance plane of the image. The local details of an image can be accessed or addressed through the luminance only. There is effect of hue and saturation also in the contrast but the effect is less compared to luminance of an image. The luminance portion is responsible for the local radiance of the image. The luminance is enhanced by applying the proposed algorithm and it is combined with the chrominance and converted back to color image. Generally the global method is very fast in processing.

IV. Implementation and Results

To see the effect of the combination of local and global enhancement methods of an image, the above mentioned algorithm is applied. The color image or digital color image to be enhanced is taken and converted to the HSV color space in order to apply the algorithm. The image plane slicing is performed and the image is divided into three different planes each of hue, saturation and value. The hue and saturation is the chrominance of the image and the value is the luminance. The luminance is mainly responsible for the radiance and brightness of the image. So the value image plane which is the third plane is taken for the enhancement and the other two planes of the image is kept as it is without altering the pixel intensities.

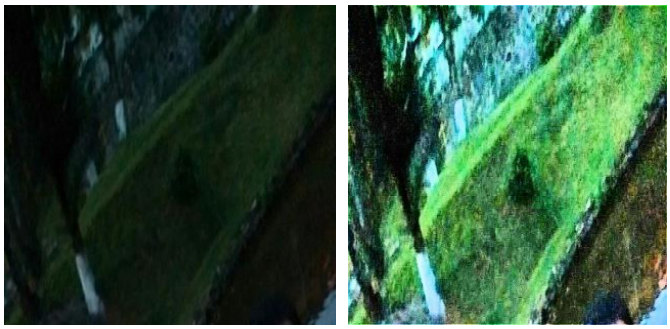
In order to enhance the edges which are considered as the local features of an image, the local contrast stretching process is applied. This is the first step in enhancement method. At the end of this step, a locally enhanced image is obtained. It gives a clear picture of the local information of the image but deficient in the overall brightness of the image. In order to address this discrepancy of local enhancement the global enhancement method is applied to the output of the first step. The global enhancement method employed here is histogram equalization explained above. The working of the algorithm can be verified with the help of image quality parameters. One

(i) Original image (ii) Enhanced image

(a) Low light image

(i) Original image (ii) Enhanced image

(b) shadow afternoon image



(i) Original image (ii) Enhanced image

(c) Evening image

Fig. 2. Input and enhanced output images of different images using proposed enhancement method.

of the very common parameter is the measure of enhancement and measure of enhancement factor (MEF). In order to find the MEF the measure of enhancement of the input and output have been calculated individually. MEF is the ratio of the measure of enhancement of output image to the measure of enhancement of the input image. A better value of MEF implies that the visual quality of the enhanced image is good. The mean of the input original image and enhanced output image is also calculated. The comparisons between input and output image is performed and shown in Table I. The original images and its enhanced images by performing proposed algorithm are shown in Fig. 2. It is also compared with some of the existing methods such as HE, DST as shown in Fig. 3.

TABLE I. COMPARISON BETWEEN INPUT AND OUTPUT IMAGES

SI. no	Image name	Input mean value	Output mean value	MEF
1	Low light image	0.37	0.42	1.75
2	Shadow afternoon image	0.38	0.4	3.05
3	Evening image	0.37	0.38	2.95

(a) HE (b) DST (c) Proposed

Fig. 3. Comparison of enhanced images: (a) HE (b) DST (c) Proposed

V. CONCLUSION

The method is successfully carried out in MATLAB. Combination of both local and global contrast enhancement techniques are employed to improve the visual quality of an image, where a local enhancement method is applied first to enhance the local details of the image, which is not taken care and usually neglected in the global contrast enhancement. The locally enhanced image is given to the input of global enhancement for better visual perceptions and increases the brightness to a level which gives pleasant sensation to the human eye. This method works fine in most of the dark images. It has more significance to those images where we need local minute gradient information such as the image of planetary and heavenly bodies, satellite images and medical images. The comparison is done with a couple of the existing methods. The different local and global methods have been used and tested their effectiveness of the different combinations of the local and global methods.

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