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Image Enhancement Through Logarithmic Transformation

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Abstract— Image enhancement play an important role in Image processing and analysis. The enhancement techniques are Retinex algorithm, Unsharp masking and Histogram equalization. Here naturalness is essential for image enhancement to achieve pleasing perceptual quality. These algorithms can efficiently extract the details of images, they are prone to destroy the naturalness. In order to preserve naturalness while enhancing details, an enhancement algorithm for naturalness preservation is proposed to assess enhanced images. Firstly the measurement for naturalness preservation via Lightness Order Smoothing is done, secondly, decomposition of image via wavelet and thirdly, the process of transformation of image is carriedout so that the illumination will not flood the details which may happen due to spatial variation while lightness-order is preserved. Experimental result demonstrates that the proposed algorithm cannot only enhance the details but also preserve the naturalness of images.

Keywords— Image enhancement, lightness order smoothing, image decomposition, wavelet decomposition, logarithmic transformation.

I. Introduction

This Image enhancement is basically improving the interpretability or perception of information in images for human viewers and providing `better' input for other automated image processing techniques. The principal objective of image enhancement is to modify attributes of an image to make it more suitable for a given task and a specific observer. The enhancement methods can broadly be divided in to the following two categories:

In spatial domain techniques, we directly deal with the image pixels. The pixel values are manipulated to achieve desired enhancement. In frequency domain methods, the image is first transferred into frequency domain. Its means that, these enhancement operations are performed in the Fourier Transform of the image is computed first. All the enhancement operations are performed on the Fourier transform of the image and then the Inverse Fourier Transform is performed to get the order to modify the image brightness, contrast or the distribution of the grey levels. As a consequence the pixel value (intensities) of the output image will be modified according to the transformation function applied on the input values.

There are some techniques used in image enhancement they are Retinex algorithm, Unsharp mask algorithm and Histogram Equalization. Retinex is an image enhancement algorithm that is used to improve the contrast, brightness and sharpness of an image primarily through dynamic range compression[4]. The algorithm also simultaneously provides color constant output and thus it removes the effects caused by different illuminants on a scene. It synthesizes contrast enhancement and color constancy by performing a non-linear spatial/spectral transform. The original algorithm is based on a model of human vision’s lightness and color constancy. Retinex belongs to the class of center surround functions, where each output value of the function is determined by the corresponding input value (center) and its neighborhood (surround). For Retinex the center is defined as each pixel value and the surround is a Gaussian function[4].

Histogram Equalization is a method in image processing of contrast adjustment using image histogram. An image histogram is a type of histogram that acts as a graphical representation of the tonal distribution in a digital image. It plots the number for each tonal value. The horizontal axis of the graph represents the tonal variations, while the vertical axis represents the number of pixels in that particular tone[5]. Unsharp Masking is an image sharpening technique, often available in digital image processing software. The “Unsharp” of the name derives from the fact that the technique uses an unsharp, positive image to create a mask of original image. The unsharped mask is then combined with the negative image, creating an image that is less blurry than the original[2].

The main function of the proposed algorithm can not only enhance the details, but also maintains the naturalness for the non-uniform illumination images. The images enhanced by the proposed algorithm are visually pleasing, artifact free, and natural looking. By using lightness order smoothing the size of original image has reduced while scaling factor increases and entropy also decreases while intensity increases when scaling factor increases, dimension reduced and remain constant. Using wavelet decomposition for different levels size, dimension and entropy all are same but increasing the levels Intensity decrease and then increasing. By logarithmic transformation by increasing the scaling factors size and dimension increased and then remain constant. Normalized cross correlation is increased whereas entropy reduces. Intensity, Normalized absolute error, and Mean square error increased and then decreased then remain constant by increasing the scaling factor.

II. Related Work

In [1] authors make for preserving the naturalness by using retinex algorithm, unsharp masking and histogram equalization and enhancing details for non uniform illumination images. The ambience of the image should not be changed greatly after enhancement, no light source should be introduced to the scene, no halo effect should be added and no blocking effect should be amplified due to over-enhancement. Some natural enhancement algorithms based on Retinex theory are proposed to enhance details with the naturalness preserved. However, these algorithms are not suitable for non-uniform illumination images. Therefore, they propose a naturalness preserved enhancement algorithm for non-uniform illumination images in this paper, which not only enhances the details of the image but also preserves the naturalness. A LOE measure, which performs well in accordance with objective assessment on naturalness preservation, is proposed as well. Experimental results demonstrate that the images enhanced by the proposed algorithm are visually pleasing, artifact free, and natural looking. In [2] authors used unsharp masking is used for sharpness enhancement. Simultaneously enhanced contrast. Reducing the halo effect and finally solving the out-of-range problem. In [3] author used an adaptive filter that controls the contribution of the sharpening path in such a way that contrast enhancement occurs in high detail areas and little or no image sharpening occurs in smooth areas. The adaptive filter does not perform a sharpening operation in smooth areas, and therefore the overall system is more robust to the presence of noise in the input images. The system is less sensitive to noise present in the input image. In [4] author used the Retinex algorithms are used to balance the illumination and to eliminate the shadow. It show very good reducing of the impact of uneven illumination and the presence of shadows and reducing the noise. In [5] author It can produce the output image with the mean intensity almost equal to the mean intensity of the input, thus fulfill the requirement of maintaining the mean brightness of the image. In BPDHE there is no parameter need to be tuned. BPDHE can enhance the images without introducing unwanted artifacts, while at the same time maintain the input brightness.

III. METHODOLOGY

A. *Description of the Proposed Algorithm:*

Aim of the proposed algorithm is to enhance the details but also maintain the naturalness of an image and performance measurement . The proposed algorithm is consists of three main steps.

Step 1: Calculating Lightness Order Smoothing:

The lightness order smoothing method aiming to enhance the details and preserving the naturalness simultaneously. It captured light which composed of reflex lightness (the lightness observed when illumination is uniform) and ambience illumination (the lightness observed when reflectance is uniform). The reflex lightness determines the details and the ambience illumination has an import impact on the naturalness.

Step 2: Decomposition of Image:

Image decomposition means to decompose the image or to divide, to separate the components of an image. It can be done by wavelet decomposition. For understanding a wavelet decomposition firstly discuss wavelet, types and wavelet families. Wavelet Decomposition is multilevel 2-D wavelet decomposition. Wavelet decomposition produces a family of hierarchically organized decompositions. The selection of a suitable level for the hierarchy will depend on the signal and experience. Often the level is chosen based on a desired low-pass cutoff frequency. At each level j, we build the j-level approximation Aj, or approximation at level j, and a deviation signal called the j-level detail Dj, or detail at level j. We can consider the original signal as the approximation at level 0, denoted by A0. The words approximation and detail are justified by the fact that A1 is an approximation of A0 taking into account the low frequencies of A0, whereas the detail D1 corresponds to the high frequency correction.

Step 3: Image Transformation:

Image transformations typically involve the manipulation of multiple bands of data, whether from a single multispectral image or from two or more images of the same area acquired at different times (i.e. multi temporal image data). Either way, image transformations generate "new" images from two or more sources which highlight particular features or properties of interest, better than the original input images.

Basic image transformations apply simple arithmetic operations to the image data. Image subtraction is often used to identify changes that have occurred between images collected on different dates.

Image transformation can be done by logarithmic transformation so it can be explain below:

The log transformation can be used to make highly skewed distributions less skewed. This can be valuable both for making patterns in the data more interpretable and for helping to meet the assumptions of inferential statistics. Fig.1 shows an example of how a log transformation can make patterns more visible. Both graphs plot the brain weight of animals as a function of their body weight. The raw weights are shown in the upper panel; the log-transformed weights are plotted in the lower panel.

Fig.1. Scatter plots of brain weight as a function of body weight in terms of both raw data (upper panel) and log-transformed data (lower panel). It is hard to discern a pattern in the upper panel whereas the strong relationship is shown clearly in the lower panel. The comparison of the means of log-transformed data is actually a comparison of geometric means. This occurs because, as shown below, the anti-log of the arithmetic mean of log-transformed values is the geometric mean. Table 1 shows the logs (base 10) of the numbers 1, 10, and 100. The arithmetic mean of the three logs is $(0 + 1 + 2)/3 = 1$. The anti-log of this arithmetic mean of 1 is $10^1 = 10$ which is the geometric mean $(1 \times 10 \times 100)^{.3333} = 10$.

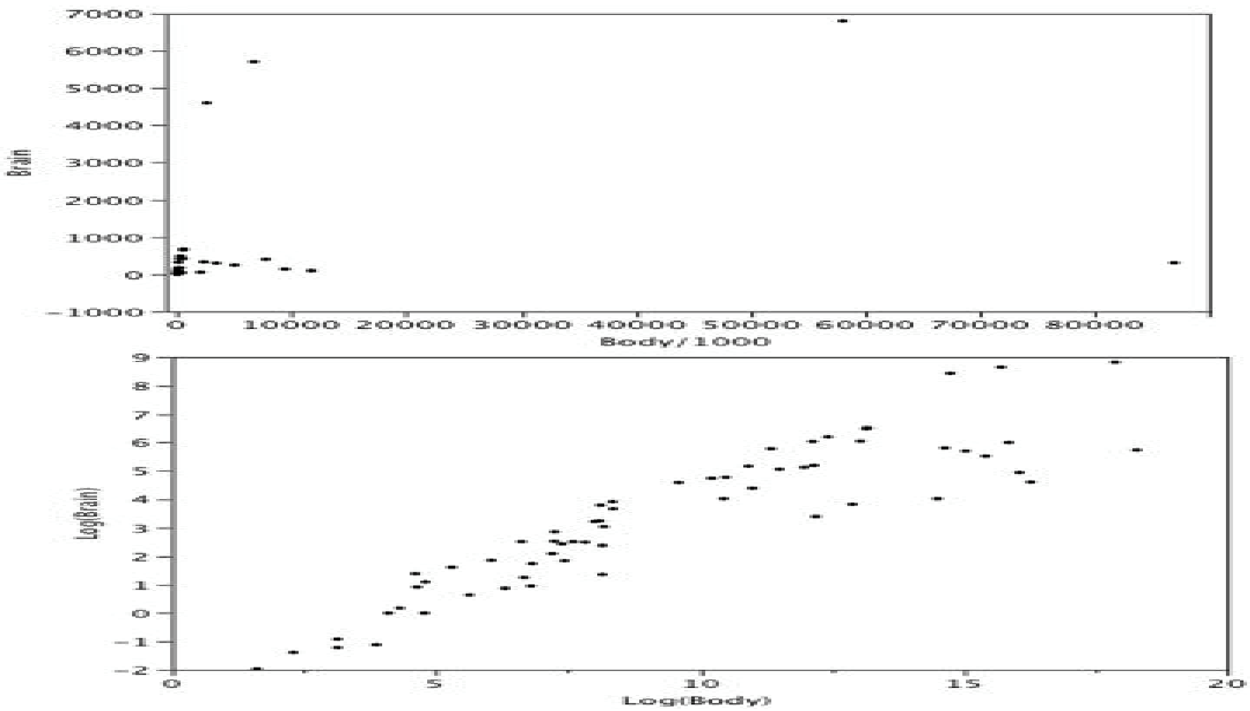

Table 1. Logarithms.

X	$Log_{10}(X)$
1 10 100	0 1 2

Therefore, if the arithmetic means of two sets of log-transformed data are equal, then the geometric means are equal. Log transformation in general in shown by this equation

$$s=c\log(1+r) \quad (1)$$

It used to expand the values of dark pixels in an image while compressing the higher values. It compresses the dynamic range of images with large variations in pixel value. It can have intensity range from 0 to 10^6 or higher. We cannot see the significant degree of detail as it will be lost in the display. Example of image with dynamic range: Fourier spectrum Image. As discussed above applying log transformation to an image will expand its low valued pixels to a higher level and has little effect on higher valued pixels so in other words it enhances image in such a way that it highlights minor details of an image as shown in figure below. Image (a) has minor details which are not much prominent but after applying log transformation we are able to see those little details.

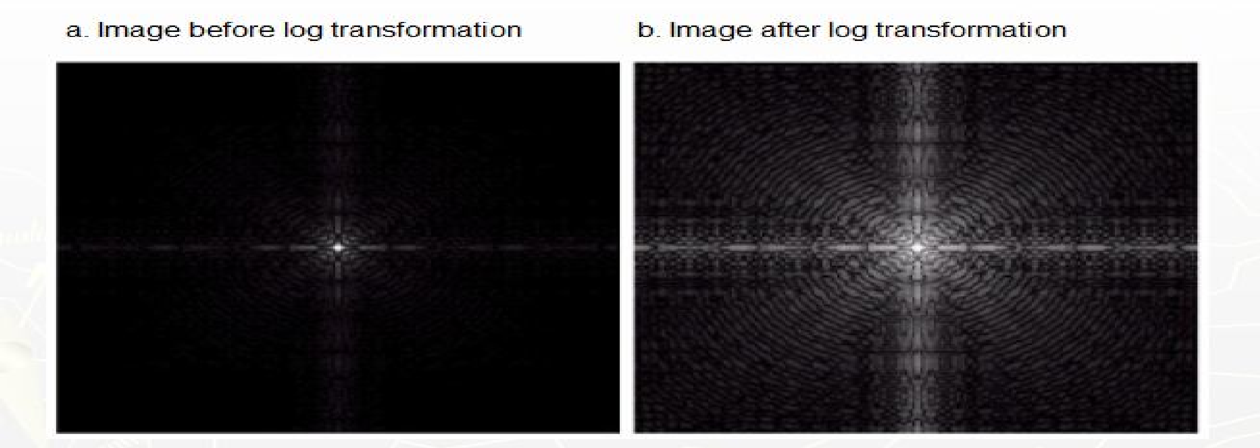

Fig.2 Image of Logarithmic Transformation

Graph:

The log transformation has a graph as shown below in this you can easily see that how it is shifting low intensity grey-level values to high values while having a little or no effect on higher intensity pixels.

Fig.3 Log Transformation Curve

IV **SIMULATION RESULT**

The simulation studies involve the naturalness preservation via lightness order smoothing as shown in Fig.4 which enhance the details and preserved the naturalness. The Table 2 shows that the size of original image has reduced while scaling factor increases and entropy also decreases while intensity increases when scaling factor increases, dimension reduced and remain constant. The decomposition of images via wavelet decomposition as shown in fig.5 and Table 3 shows that for different levels size, dimension and entropy all are same but increasing the levels Intensity decrease and then increasing. By transformation image as shown in Fig. 6. From Table 4 by increasing the scaling factors size and dimension increased and then remain constant. Normalized cross correlation is increased whereas entropy reduces. Intensity, Normalized absolute error, and Mean square error increased and then decreased then remain constant by increasing the scaling factor.

Original Image

Lightness Order Smoothing Image

Fig.4. Lightness order smoothing Image

Table 2

Original Image		**Lightness Order Smoothing**			
Parameters / Scaling factor	0.05	0.04	0.05	0.06	0.07
Size	381 kb	26.1 kb	24.9 kb	23.8 kb	22.9 kb
Dimension	768*784	688*598	688*598	688*598	688*598
Entropy	7.886	7.7125	7.6762	7.6089	7.5474
Intensity	0.02	0.0273	0.0278	0.0283	0.0288

Gray Image(Input Image)

Decomposed Image

Fig.5 Decomposition Image

Table 3

Original Image		**Decomposition Image**		
Parameters / Levels		Level 2	Level 3	Level 4
Size	26.8 Kb	26.8 Kb	26.8 Kb	26.8 Kb
Dimension	434*476	434*476	434*476	434*476
Intensity	24.0074	16.0050	16.0051	16.0052
Entropy	7.2484	7.2484	7.2484	7.2484

Decomposed Image

Transformed image

Fig. 6 Transformed Image

Table 4

Input Image		**Transformed Image**		
Parameters / Scaling factors		1.5	2	3
Size	26.8Kb	31.8Kb	31.8Kb	31.8Kb
Dimension	434*476	562*599	562*599	562*599
Entropy	7.2484	5.5173	4.934	1.8093
Intensity	16	666.010	491.12	491.011
Mean Square Error	0.0125	7.1456e+003	1.1503e+004	1.1503e+004
Peak Signal – To – Noise Ratio	67.1706	9.5904	7.5229	7.5229
Normalized Cross Correlation	1.000	1.2683	1.5333	1.5333
Normalized Absolute Error	5.9145e-005	0.5178	0.7267	0.7264

V CONCLUSION

T The simulation results showed that the proposed algorithm can not only enhance the details, but also maintains the naturalness for the non-uniform illumination images. The images enhanced by the proposed algorithm are visually pleasing, artifact free, and natural looking.

Using lightness order smoothing the size of original image has reduced while scaling factor increases and entropy also decreases while intensity increases when scaling factor increases, dimension reduced and remain constant. By using wavelet decomposition for different levels size, dimension and entropy all are same but increasing the levels Intensity decrease and then increasing By logarithmic transformation by increasing the scaling factors size and dimension increased and then remain constant. Normalized cross correlation is increased whereas entropy reduces. Intensity, Normalized absolute error, and Mean square error increased and then decreased then remain constant by increasing the scaling factor.

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