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Development of an Image Enhancement Method and a GUI

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Abstract

This article introduces a new adaptive local image enhancement method and a graphical user. The algorithm for image enhancement will correct contrast for some certain areas of an image which is based on edges contained in the image and some statistical properties; variance of the whole image and mean value of an image block. A contrast correction gain is chosen for each image tile based on statistical properties. The algorithm improves the visual quality of an image and also restricts noise amplification. The algorithm is tested with grayscale images and results are compared with histogram equalization and adaptive histogram equalization techniques by image quality metrics parameters.

Keywords: *Image Enhancement, SNR, PSNR, AMBE, RMSE, Region of Interest, GUIDE*

1. Introduction

In this modern age everything is going digital and that also has affected the image capturing techniques. Invention of digital cameras reduced cost and saves time of image capture, but that also has put some challenges to digital processing of captured images. The quality of digital picture has now become the main concern as image brightness and sharpness are the encountered issues with digital imaging technique. Here comes the necessity of image enhancement, and that's why it has attracted various researchers to work in this field.

Image enhancement is a process of changing the pixels intensity of the input image; to make the output image subjectively look better. Image enhancement methods can be broadly classified as spatial domain and frequency domain transformation. [1-17] Shows several image enhancement related research articles. [1] Shows a localized image enhancement method, where they provided a fast algorithm to increase contrast of an image locally using singular value decomposition (SVD) approach. In [2] a novel fuzzy enhancement operator with close-character and transplantable-character was proposed in the paper for image enhancement. The approached method employs the gradient operator to make the image enhancement processing focus on the interested regions, and the OTSU operator to automatically select the best threshold value, which can realize a novel adaptive fuzzy image enhancement algorithm for local regions. [3] Represents a method of image enhancement, which only depends on the difference of grey values of adjacency flat zones of an image, is proposed according to the theory of morphological reconstruction. [4] Shows a generalized equalization model for image enhancement. According to them an optimal image enhancement algorithm is proposed that theoretically achieves the best joint contrast enhancement and white balancing result with trading-off

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between contrast enhancement and tonal distortion. In [5] a kind of hybrid intelligent algorithm was proposed in the paper which optimizes parameters of image enhancement operator which uses local gray distribution and the global statistical information of source image. [6] Proposes an image enhancement method for high contrast image and having wide dynamic range. It is based on a two-scale decomposition of the image into a base layer, encoding large-scale variations, and a detail layer. Article [7-8] represents a review work which shows several available method of contrast adjustment.

In paper [9], another method for image contrast enhancement was presented with a mapping function, which was a mixture of global and local transformation functions that improve both the brightness and fine details of the input image. A Multi-Decomposition Histogram Equalization (MDHE) technique was proposed in [10], where they decomposed the input image using a unique logic and applied CHE (Classical Histogram Equalization) in each of the sub-images and then finally interpolated them in correct order to reconstruct the image. Other research papers [11-16] also showing several techniques for preserving brightness while performing contrast adjustment by local and global methods with histogram equalization.

The work done here is quite different from [1-16] in the sense that it is restricting noise by only correcting the contrast in some certain part of an image by a contrast gain parameter which is set by statistical properties and edges contained in the image. The work also employs design of an interactive graphical user interface in MATLAB where the proposed algorithms along with other available image processing functions are bundled. The remainder of the paper is organized as follows: Section II shows basic working methodology, Section III shows proposed algorithm, Section IV & V shows graphical user interface and some image quality measurement parameters, Experimental result are provided in Section VI, Finally the paper is concluded in section VII.

2. Working Principle

The methodology is shown in Figure 1. First the image is loaded and converted into gray scale image. Then the whole image is sub divided into several image tiles or windows. The algorithm will be working on each tile of the image, with the basic formula: B= A * Con+ Bri, where B is the output tile image, A is the input tile image, (Con) is a contrast correction parameter and (Bri) is brightness correction parameter. Value of parameters (Con) and (Bri) is set based on edge parameter and statistical parameters of the image and each image window which is discussed in algorithm section.

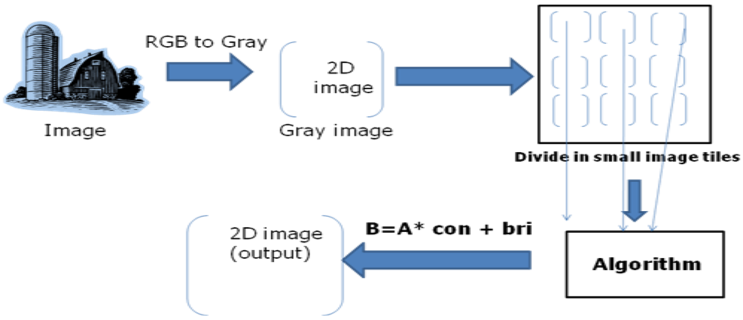

Figure 1. Basic Working Principle

3. Algorithm

Figure 2 shows the flowchart of the algorithm for performing image enhancement. According to the algorithm 1st the input image will be loaded in 2D matrix (gray image).Then the algorithm will search for the parameters (k, m, n), where k is contrast gain parameter and m, n are window parameter. According to the algorithm standard deviation of input image will be calculated and then stored in p. After that Edge detected version will be calculated and stored in B. Then window of size m x n is selected as the region of interest from the input image. The same size of window and region of interest is also selected from edge detected image. Mean values of both the windows are calculated and then stored in q & r respectively. After this a flow control segment is there which q is, <=r and r==0. The significance of this flow control is to allow contrast correction while preserving edges contained in the image. If the condition is satisfied then contrast correction is applied. Then window pixels are amplified by the contrast gain parameter k (formula is window=window. * k). The output window will be placed to a new matrix C in appropriate ROI (Region of Interest). After that, algorithm will check whether the processing is complete for the whole image or not; if yes the resulted image is stored in C; if not the algorithm will proceed to the next window and in this way it will be rounding unless the whole image is processed.

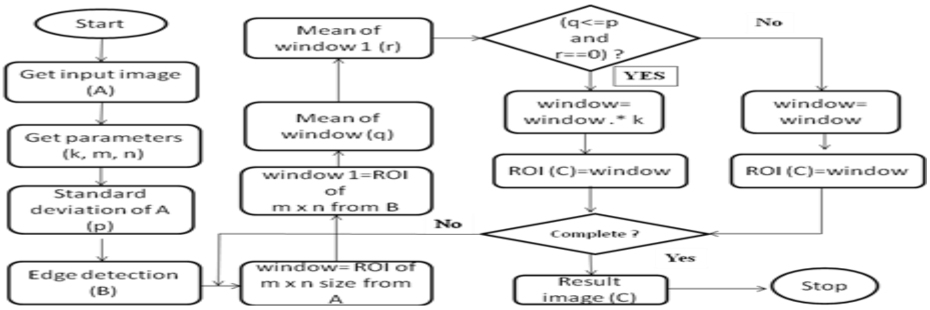

Figure 2. Flowchart of the Proposed Algorithm

4. Graphical User Interface

GUIDE, the MATLAB graphical user interface development environment, provides a set of tools for creating graphical user interfaces (GUIs). An interactive graphical user panel is created with image processing capabilities and is shown in Figure 3. The GUI includes several image processing capabilities like RGB to gray, RGB to black and white, RGB to negative conversion and couple of basic image enhancement functions along with the proposed image enhancement algorithm. The GUI panel here contains radio buttons, text box, axis box, sliders and push button components.

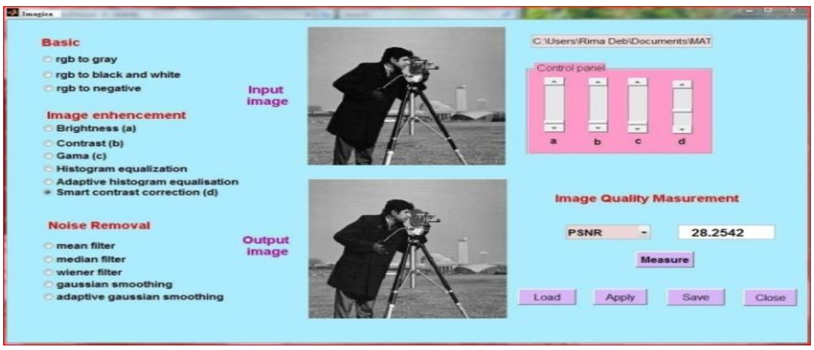

Figure 3. GUI with Image Processing Features

5. Image Quality Measurement Parameters

This section briefly describes several image quality measurement tools which are used to determine the quality of a processed image with respect to the original image. These parameters can be used for comparison between several image enhancement techniques.

A. Absolute Mean Brightness Error (AMBE)

This parameter is used to estimate the performance to preserve the original brightness of an image and called as Absolute Mean Brightness Error (AMBE). It is defined as the absolute difference between the mean of the input and the output images and represents the deviation of brightness of processed image with respect to the original image.

$$AMBE=|E\,(A) - E\,(B)| \tag{1}$$

E (A) and E (B) are statistical mean of input image (A) and output image (B). Lower AMBE indicates the better brightness preservation of the image.

B. Peak Signal-to-Noise Ratio (PSNR)

Peak Signal-to-Noise Ratio (PSNR) property is used to evaluate the trait of contrast enhancement. Greater the value of PSNR better the contrast enhancement of the image.
Let, A (i, j) is a source image that contains m by n pixels and the reconstructed image B (i, j). The pixel values of image
A (i, j) range between black (0) and white (255). First, the mean squared error (MSE) of the reconstructed image is calculated as:

$$\text{MSE}=\frac{\sum_{i=1}^{m}\sum_{j=1}^{n}[A(i,j)-B(i,j)]^2}{m\times n} \tag{2}$$

The root mean square error (RMSE) is computed from root of MSE. Then the PSNR in decibels (dB) is computed as:

$$\text{PSNR} = 20log_{10}\left(\frac{Max\ (B(i,j)}{RMSE}\right) \tag{3}$$

C. Signal to Noise Ratio (SNR)

It establishes the relation between input signal level and surrounding noise level and defined as the ratio of signal power to noise power. It is measured in Decibels and represented as:

$$SNR_{dB}= 10log_{10}\left(\frac{P_{signal}}{P_{noise}}\right) = P_{signal,dB} - P_{noise,dB} \tag{4}$$

6. Simulation Result

A. Original image description

Figure 4 is the original image ‘cameraman.tif’ and Figure 5 is the corresponding histogram plot. If we carefully observe the image we will see the right hand portion of the cameraman is not properly visible. This can be corrected using several image enhancement algorithms like Histogram equalization or adaptive histogram equalization.

B. Histogram Equalization of the original image

After applying histogram equalization technique to the original image we got an improved quality image, Figure 6, where the hand of the cameraman is slightly visible along with the PSNR value of 19.0970 but brightness of the image shifts to the central region. The respective histogram plot is shown in Figure 7.

C. Adaptive Histogram equalization of the original image

While applying the adaptive histogram equalization technique to the original image we got improved quality image, Fig.8, than the histogram equalized image. The PSNR value of the adaptive histogram equalized image has also improved to 21.1434. The corresponding histogram plot is shown in Fig.9.

D. Proposed algorithm: Smart Contrast Correction

We have developed a new and adaptive Smart Contrast Correction algorithm. We can visualize the improved quality of the processed image and can easily identify the right hand portion of the cameraman in Fig.10. Histogram plot for that is shown in Fig.11. We can clearly see the PSNR (28.2542) improvement is more compared to other techniques.

The quantified results are tabulated in Table 1, where the results are based on image quality parameters PSNR, RMSE and AMBE.

Figure 4. Cameraman.tif, Original

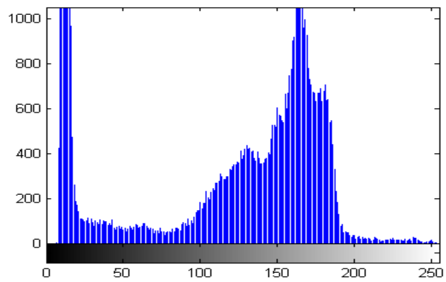

Figure 5. Histogram of Cameraman.tif, Original

Figure 6. Histogram Equalized Image

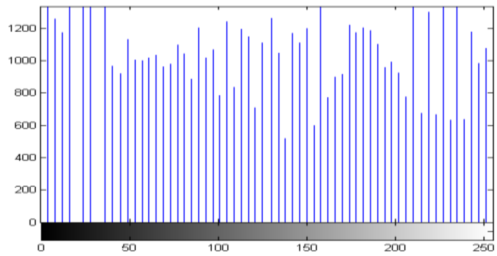

Figure 7. Histogram Plot of Histogram Equalized Image

Figure 8. Adaptive Histogram Equalized Image

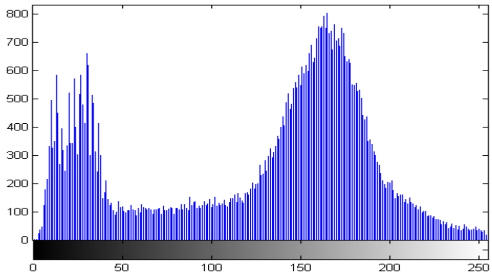

Figure 9. Histogram Plot for AHE Equalized Image

Figure 10. Enhanced Image with Proposed Algorithm

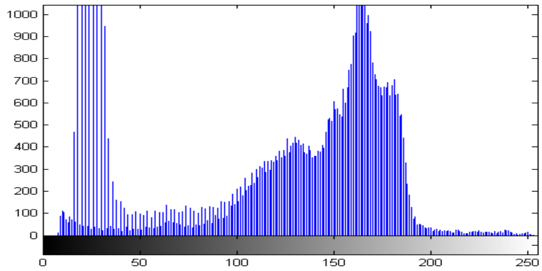

Figure 11. Histogram Plot of the Processed Image with Proposed Algorithm

Table 1. Different Image Quality Assessment Parameters for Each Used Algorithm

Algorithm	AMBE	RMSE	PSNR
Histogram Equalization	8.6955	28.301	19.0970
Adaptive Histogram Equalization	7.2115	22.3684	21.1434
Proposed method	3.7226	9.8607	28.2542

7. Conclusion

A new and adaptive image enhancement algorithm is developed and tested, which will enhance images and also restricts noise amplification. We also have developed an easy to use and attractive GUI panel in Matlab where several image processing algorithm is included along with the proposed algorithm. The results obtained here are satisfactory and suited for real time application.

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