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A SYSTEMATIC STUDY OF WIDELY USED IMAGE LOCAL CONTRAST ENHANCEMENT METHODS

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Abstract
Image contrast is one of the main characteristic of an image. Image contrast is defined as the difference in luminance in color or some other information in the foreground and background that makes an object visible. Low contrast images have poor visibility and these images lack to provide a clear view of the information that they contain. For increasing visibility in such images the image contras enhancement methods are used. These methods are broadly divided into two parts, local contrast enhancement techniques and global contrast enhancement techniques. There are many techniques for enhancing local contrast of image that leads to the appearance of image brighter and hence contents of the image are clearly visible. In this paper we are going to provide a systematic study of few widely used image local contrast enhancement method

Keywords: *Image Enhancement, Local Contrast Enhancement, Brightness Preservation.*

Introduction

Generally people prefer good quality pictures or images. However, all the pictures or images are not always having good quality depending on various factors like recording, recording device, light incident on the objects and processing etc. One of the low quality images is the low contrast image type. Low contrast images are having narrow range of intensity levels of the pixels of the image. To improve the visual quality of low contrast images, different enhancement can be done in different domain like spatial domain, frequency domain etc. Local contrast enhancement is considered as important characteristic in the field of digital image processing. It is mainly used for texture synthesis, medical image processing, speech recognition and various other applications [1].

Global contrast enhancement techniques [1]-[5] work fine, fast and simple for some kind of images. It improves the quality of the image globally; however, the quality of the local contrast is poor in some images. One of the widely utilized global enhancement methods is histogram equalization. Global Histogram Equalization (GHE) is very effective and the most appropriate enhancement method for some images. However, GHE is not always desirable [6], because it produces the image over enhanced in some portions and some properties of the image cannot be defined properly. Since the image characteristics differ considerably from one region to another in the same image, the enhancement techniques based on local contrast are necessary. There are several local contrast enhancement methods. In this work we are going to provide a systematic study of the following local contrast enhancement methods.

1. Adaptive Histogram Equalization.
2. Contrast Limited Adaptive Histogram Equalization.
3. Modified Contrast Limited Adaptive Histogram Equalization Based on Local Contrast Enhancement for Mammogram Images.
4. Adaptive Contrast Enhancement Using Local Region Stretching.
5. Local Contrast Enhancement using Local Standard Deviation.
6. Local Histogram Processing.
7. Image Local Contrast Enhancement Using Grey Relational Analysis.

The organization of this work is as follows. After providing a brief introduction in section 1, in section 2 we will provide a review of local contrast enhancement algorithms. Finally section 3 concludes the entire context.

Image Local Contrast Enhancement Methods

In this section we will provide a review of local contrast enhancement algorithms.

A. Adaptive Histogram Equalization (AHE)

Adaptive histogram equalization [6] (AHE) is a technique of image contrast enhancement used in digital image processing. It is different from conventional histogram equalization technique in the way that the AHE computes various histogram equalization independently, each of which belongs to different sections of images. The main advantage of AHE is that it is able to enhance the local contrast of image and hence, preserve more brightness.

Conventional histogram equalization uses the same transformation to transform all pixels. HE proves better in cases where pixels values are distributed uniformly in the image. But fails in cases where image consists of different brighter and darker regions as it is not able to enhance these regions.

AHE overcomes the drawback of HE by enhancing local contrast of image. AHE enhance this transformation function by transforming each pixel values. Based on the histogram of square, which is surrounded by pixel value each pixel value is transformed as shown in figure. The pixel value of neighborhood is proportional for each transformation function and cumulative distribution function. The ordinary histogram equalization is similar to the transformation function derived from each pixel value.

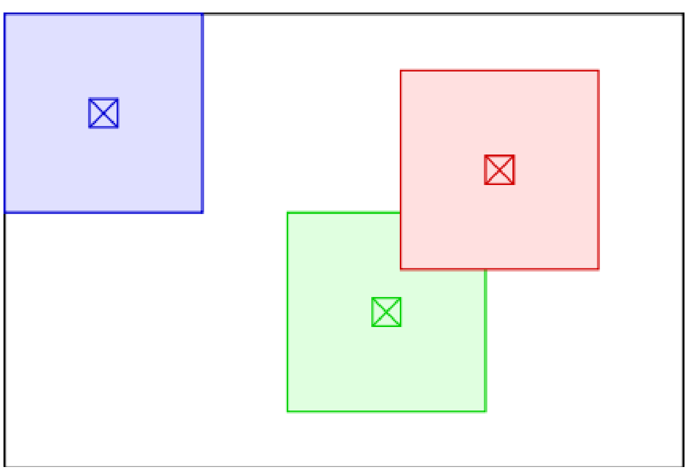

Figure 1. Processing by AHE.

B. Contrast Limited Adaptive Histogram Equalization (CLAHE)

Contrast Limited AHE (CLAHE) [8] facilitates the contrast limiting functionality that makes it different from adaptive HE. AHE is able to enhance the local details only, while contrast limiting functionality of CLAHE is able to enhance the global details as well. The main advantage of CLAHE is that it is able to prevent distortions like noise amplification which is not in case of AHE. The contrast limiting functionality of CLAHE is applied for each neighbor from whom we derive transformation function.

CLAHE performs noise amplification by applying contrast limiting functionality in AHE. The slope of transformation function determines the contrast amplification for each of the pixel value and the area surrounded by pixel value. This is similar to the value of histogram for each pixel value. It is also similar to the slope of cumulative distribution function (CDF). CLAHE perform this amplification function by trimming the part of histogram before applying the CDF which simply leads to limit the slope of transformation. Depending on the normalization of this histogram, clip limit is the term defined as the value through which histogram is trimmed.

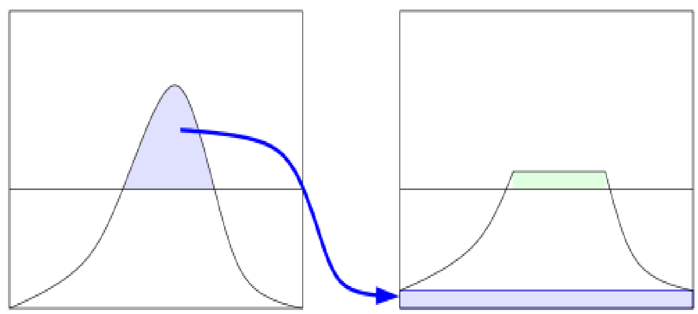

Figure 2. Contrast limitation by CLAHE.

C. Modified Contrast Limited Adaptive Histogram Equalization (MCLAHE)

This method [9] uses a local contrast enhancement to highlight the fine details hidden in the mammogram image and an enhancement parameter to control the level of enhancement along with standard CLAHE. So incorporating LCM with CLAHE produces an optimal contrast enhancement with all local information of mammogram images which may not be obtained using Standard CLAHE.

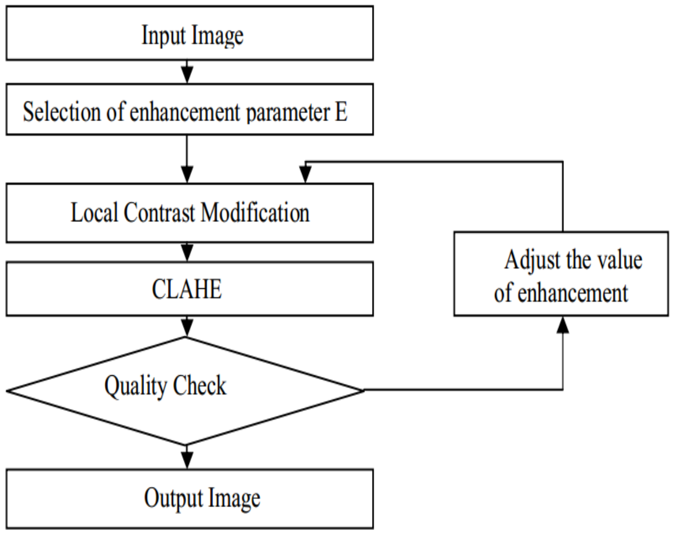

Figure-3 Flowchart of MCLAHE.

Figure 1 show the steps involved in the proposed method. The original image and the enhancement parameter is given as input to LCM .In LCM we modify the image to produce the finer details hidden in the mammogram image and that output image is give as input to CLAHE and CLAHE will further enhance the image with quality check.

D. Adaptive Contrast Enhancement Using Local Region Stretching

This enhancement technique is for digital video applications. This method called ACE [10] is based on a modified histogram equalization procedure that adapts to the input video statistics. The method decides whether to increase dynamic range or to light up dark regions of the image. As a result, for dark images, details in dark areas are enhanced without affecting mid and bright pixels. For images with average brightness, the dynamic range of the scene is increased. Thus it is adaptive and provides a localized contrast enhancement effect which is not possible with traditional contrast stretching based approaches. Unlike other histogram equalization based approaches, the technique described automatically tones down its effects on pictures that are prone to contouring and other artifacts. The algorithm called ACE calculates the amount of enhancement needed depending on the shape of the histogram. The algorithm is able to increase the contrast range for images with average brightness while lighting up darker images. As a result it produces a localized adaptive effect. It is free from the artifacts usually associated with histogram equalization and is well suited for hardware implementation

E. Local Contrast Enhancement using Local Standard Deviation

The local contrast enhancement [11] using LSD is powerful in many applications. However, for some kind of images, the pixels of some regions of the image are producing the LSD's as 0's. This is an undesired limitation that divide by zero may not be working or may produce undesired output image. This method eliminates the divide by zero condition by increasing the window size or by modifying the values of LSD's of the image.

F. Local Histogram Processing

The local contrast method is obtained by using some statistical parameters from the histogram [12]. Let r denotes a discrete random variable representing discrete gray levels in the range [0, L−1] and let P (r_i) is the normalized histogram component corresponding to the ith value of r. The nth moment of r about its mean is defined a equation (1)

$$\mu_n(r) = \sum_{i=0}^{L-1} (r_i - m)^n P(r_i) \qquad (1)$$

Where m is the mean value of r equation (7)

$$m = \sum_{i=0}^{L-1} r_i P(r_i) \qquad (2)$$

From equation (1) and (2), $\mu_0 = 1$ and $\mu_1 = 0$. The second moment is given by equation (3)

$$\mu_2(r) = \sum_{i=0}^{L-1} (r_i - m)^2 p(r_i) \qquad (3)$$

The equation (3) is the variance of r, which is denoted by σ^2(r). The mean is measure of average gray level in an image and the variance or standard deviation is a measure of average contrast. In this work, the local mean and variance are used as the basis for local contrast enhancement. Let S_{xy} denote a sub-image of size w_x, w_y centered at (x, y), the mean value $m_{S_{xy}}$ of the pixels in S_{xy} can be computed as follows equation (4)

$$m_{S_{xy}} = \sum_{(s,t)\in S_{xy}} r_{s,t} P(r_{s,t}) \qquad (4)$$

Where $r_{s,t}$ is the gray level at co-ordinates (s, t) in the neighborhood defined by the sub-image and P ($r_{s,t}$) is the neighborhood normalized histogram component to that value of gray level. The gray level variance of the pixels in region S_{xy} is given by equation (5)

$$\sigma^2 = \sum_{(s,t)\in S_{xy}} [r_{s,t} - m_{S_{xy}}]^2 P(r_{s,t}) \quad (5)$$

The local contrast enhancement for the mammogram image is obtained by applying the following equation (6) after the histogram-modified image is obtained.

$$g(x,y) = \begin{cases} E.f(x,y), & \text{if} \quad m_{S_{xy}} \le K_0 M \\ & \text{and} \quad K_1 D \le \sigma_{S_{xy}} \le K_2 D \\ f(x,y), & \text{Otherwise} \end{cases} \quad (6)$$

Where g(x, y) and f(x, y) are final enhanced and histogram modified images respectively and E, K_0, K_1 and K_2 are specified parameters. M is global mean of the input image applied to LCE method and D is its global standard deviation. E, K_0, K_1 and K_2 are positive constants with $K_0 < 1$, $K_1 < K_2$ and K_2 is greater than 1 for enhancing light areas and less than 1 for dark areas.

G. Image Local Contrast Enhancement Based on Grey Relational Analysis

On the basis of GRA, a new method of image edge detection is developed. First, the method of edge detection based on GRA is discussed, and analyzes the feasibility and superiority of the method; second, this method improves the definition of the local contrast, the formulas of contrast enhancement function and their corresponding parameters in the equations. This method regard to the drawbacks of the classic method brought by Baghdadi [14], it is easy to analyze the reason for it, which is that it uses the edge detection operator such as Laplacian or Sobel operator to detect the contour and augment the contrast of the local pixels in the neighborhood. The main unreasonable part is that the present edge detector method cannot perfectly discriminate the edge pixels and non-edge ones, and the contrast enhancement function is also not very reasonable by the corresponding reason. Due to overcome the drawbacks, this method adopts a new method based on GRA, which is an indispensable branch of grey system theory, and can be used to characterize the geometric shape of the two sequences in the similarity. [13]

Conclusion

In this work we made a comparative study of widely used local contrast enhancement methods. We observed that all the methods are developed to remove drawbacks from the previously developed methods; such as CLAHE was developed to remove the problem of noise amplification of AHE. The Modified CLAHE improves the robustness of the CLAHE method. Methods based on local region stretching and local standard deviation are developed to deal with some special issues of local contrast enhancement. Local histogram processing is a statistical method that enhances contrast of given image base on local statistics. Finally the GRA method uses optimization technique for local contrast enhancement.

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