Modified Contrast Limited Adaptive Histogram Equalization Based on Local Contrast Enhancement for Mammogram Images

Conference Paper *in* Communications in Computer and Information Science · April 2012

DOI: 10.1007/978-3-642-35864-7_60

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Modified Contrast Limited Adaptive Histogram Equalization Based on Local Contrast Enhancement for Mammogram Images

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Abstract. Optimal Contrast enhancement for detection of masses and micro calcification of mammogram images using Contrast Limited Adaptive Histogram Equalization (CLAHE) based on local contrast modification (LCM) is presented in this paper. The LCM-CLAHE is proposed to highlight the finer hidden details in mammogram images and to adjust the level of contrast enhancement. The proposed method is tested for mammographic images from MIAS database. The performance of the proposed method is obtained using Peak Signal to Noise Ratio (PSNR). The results are compared with other standard enhancement techniques such as Histogram Equalization, Unsharp Masking (USM) and CLAHE. The experimental results of proposed method show that this method provides better contrast enhancement with preserving all the local information of the mammogram images.

Keywords: Local Contrast Modification (LCM), Enhancement parameter, CLAHE, PSNR, USM, HE

1 Introduction

In the present medical scenario detection of breast cancer in its early stage is a very immense challenge. Even with the advancement in medical technology it is complex to detect cancerous cells in its premature stage. Annual report on status of cancer reveals that one in eight women develops cancer in their lifetime and it is one of the major causes of death for woman in United States [1]. In breast cancer detection the critical part is a method to distinguish between normal tissues and cancerous tissues. Differentiating of this by human eye is very difficult. Mammography is the primary method in the detection of breast cancer, and it is an X-Ray imaging technique. Mammography is very effective method of finding breast diseases. Even with this effective method over 10 percent of the cancerous lesions are left undetected and also has the drawbacks like low contrast images [2].

Yogesh Chabba (Ed.): AIM 2012, pp. 282-288, 2012.

In order to deal with the low quality or low contrast X-Ray images, Image Enhancement is used. Image Enhancement helps in improving the quality and appearance of the image. Enormous research is being done in the image enhancement in medical field and various techniques has been developed which improved the image quality to a certain extend [3].

2 Related Works

Histogram Equalization (HE) is one of the popular methods for contrast enhancement which modify the gray level histogram of an image to a uniform distribution [4]. But in many cases it produces over enhancement in output image and loss of local information which leads to insufficient medical details during diagnosis. To overcome these drawbacks, many variants of HE have been proposed [5-8].

In medical imaging (such as mammogram enhancement) local contrast are more important than global contrast. In such type of applications Global Histogram Equalization (GHE) is insufficient because it cannot deal with local features of original image due to its global nature. Adaptive Histogram Equalization (AHE) method will perform throughout all pixels in the entire image and maps gray level using local histograms, but it takes more time [5]. Pizer has proposed AHE in which the input image is divided into blocks and then the mapping functions are computed for those blocks using CLAHE [7].

The standard CLAHE method produces over enhancement which results in the loss of some local information [9]. In order to overcome this limitation we have proposed LCM-CLAHE. This method will produce optimal contrast without losing any local information of the mammogram image which is most important for detection of breast cancer. The proposed method LCM-CLAHE consists of two stages of processing to increase the potentiality of contrast enhancement and to preserve the local details in the images. The details of the proposed method are presented in the next section.

3 Proposed Method (LCM-CLAHE)

Histogram Equalization uniformly distributes the intensity of the image .But it produces over enhancement in the output image which leads to the loss of local details in the mammogram images [9].AHE differs from the ordinary histogram equalization in the respect that HE generates only one histogram whereas adaptive method computes several histogram, corresponding to a distinct section of the image and uses that to redistribute the intensity values of image.AHE is a better enhancement method for medical images . However, it has a drawback of noise over amplification. CLAHE is a variant of AHE which reduces the noise amplification. Using CLAHE also we have found that it is also not so suitable for mammogram images of very fine details. In Histogram Modified (HM)-CLAHE the author have proposed global modification of histogram along with CLAHE [10].But in mammogram images local details are more important than global details for the detection of cancerous cells. So in the proposed method we have used 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.

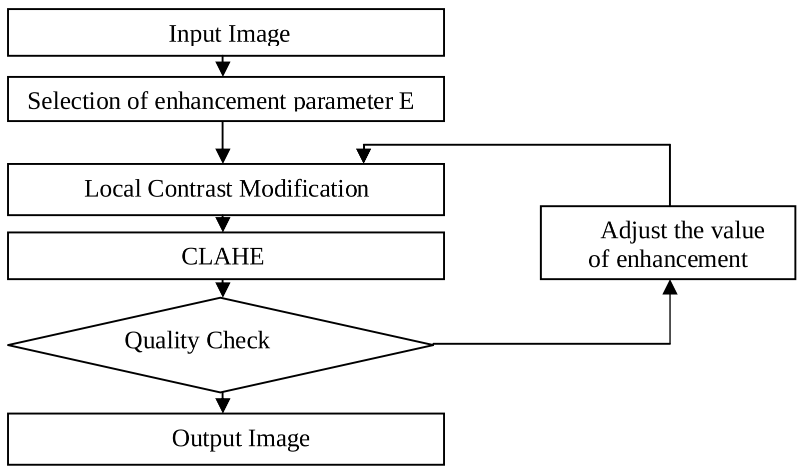

Figure 1.Flow chart of proposed LCM-CLAHE

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. The quality check used in the proposed method is PSNR. The following sections will summarize in detail the theory of LCM, CLAHE and PSNR.

3.1 Local Contrast Modification (LCM)

The first stage in the proposed mammogram image enhancement method is applying local contrast enhancement on the input mammogram image. The function used in method is designed in such a way that it takes both global as well as local information to produce the enhanced image. The local information is extracted from a user defined window of size n×n pixels. The transformation function can formulated as given below

$$T = \frac{E \, . M}{\sigma} \tag{1}$$

$$g = T * (f - m) + m \tag{2}$$

where g and f are LCM enhanced and input image respectively and E is the enhancement parameter, M is the global mean of the input image, m is the local mean and is the local standard deviation, E is a positive constant and value is in between 0 and 1. The expression for local mean and standard deviation for the user defined window is computed as follows

$$m(x,y) = \frac{1}{n \times n} \sum_{x=0}^{n-1} \sum_{y=0}^{n-1} f(x,y) \tag{3}$$

$$\sigma = \sqrt{\frac{1}{n \times n} \sum_{x=0}^{n-1} \sum_{y=0}^{n-1} \left(f(x,y) - m(x,y) \right)^2} \tag{4}$$

After getting the local mean and standard deviation of all windows, we calculate the average of this and that value is used in equation (1) and (2). This method will highlight the finer details of mammogram images .The enhanced image after this method is given as input to CLAHE.

3.2 CLAHE (Contrast Limited Adaptive Histogram Equalization)

The CLAHE method has good tractability in choosing local histogram mapping function. This method divides the image into appropriate regions and applies histogram equalization to them. It modifies the intensity values of the image by employing a nonlinear methodology in order to maximize the contrast for all pixels of the image. The clipping level selection of the histogram reduces the undesired noise amplification. In the proposed method Local Contrast Enhancement process is the first step and then CLAHE is applied to Local Contrast Modified image. By selecting optimal clipping level in CLAHE and the enhancement parameter in Local Contrast Enhancement the proposed method achieves optimum contrast enhancement for the mammogram images.

4 Experimental Results and Discussion

This section presents the experimental results of the proposed method LCM-CLAHE. In this paper, the most popular image enhancement techniques like HE, USM and CLAHE techniques are chosen in order to validate the proposed technique. The Local Contrast Enhancement in the LCM-CLAHE method preserves the local information. Determining the optimum contrast enhancement without losing fine details is a very b challenging in mammogram contrast enhancement. With the Enhancement parameter E=0.4 and clipping factor=0.015 the proposed method achieves optimum contrast enhancement for mammogram images as shown in Table 1.

Table 1 Comparison of PSNR values produced by HE, USM, CLAHE and proposed method LCM-CLAHE

Image	PSNR			
	HE	USM	CLAHE	LCM-CLAHE
mdb019	33.76	32.19	54.01	**46.09**
mdb213	29.68	35.15	53.68	**45.17**
mdb238	30.71	35.52	50.71	**43.95**
mdb076	31.01	34.58	55.34	**44.97**
mdb086	29.31	35.46	51.41	**45.97**
mdb201	34.78	30.10	50.68	**43.85**
mdb202	34.84	32.01	52.59	**43.43**
mdb218	33.04	34.00	55.04	**43.94**
mdb214	29.08	35.71	51.17	**44.39**
mdb220	33.52	32.91	50.20	**45.79**
mdb235	32.59	35.41	50.55	**43.11**
mdb239	34	31.75	53.28	**43.03**
mdb242	29.50	34.84	55.20	**45.60**
mdb243	31.26	33.74	52.99	**44.45**
mdb244	31.66	32.90	51.74	**43.51**
mdb249	31.34	33.35	52.79	**43.94**
mdb254	34.16	32.68	55.97	**44.14**
mdb280	47.23	29.11	55.73	**44.46**

5 Performance Measure

An image is said to be enhanced if it allows the viewer to better perceive the desirable information in the image. The performance measure used here is Peak Signal to Noise Ratio (PSNR) [11]. The PSNR value of an image G with respect to the original image F, both of size M×N pixels, is calculated as shown below

$$M_s = \sum_{m,n} \left[F(m,n) - G(m,n)\right]^2 \tag{5}$$

$$PSNR = 10 * \log 10 \frac{255^2}{M_s} \tag{6}$$

Where Ms is the mean Squared Error given by Equation (5).

From experimental result, it is clear that LCM-CLAHE provides an optimal contrast enhancement for image mdb235 (PSNR=43.11) without losing the finer information of original image where as for Unsharp Masking (PSNR=36.09), HE (PSNR=29.09) is not enhanced properly and CLAHE (PSNR=52.34) which shows over enhancement.

6 Conclusion

A new approach for image enhancement using Modified CLAHE based on local contrast enhancement has been presented in this paper. The proposed method provides a better contrast enhancement and information preservation of input mammogram image. The mammogram images enhanced using proposed method are satisfying both subjective and objective evaluation. The experimental results of LCM-CLAHE show that this method is more effective without compromising contrast as well as original information. All types of mammogram images like fatty, fatty-glandular and dense glandular can be enhanced effectively using this method. Currently, work is under progress for amending the proposed method for other types of medical images.

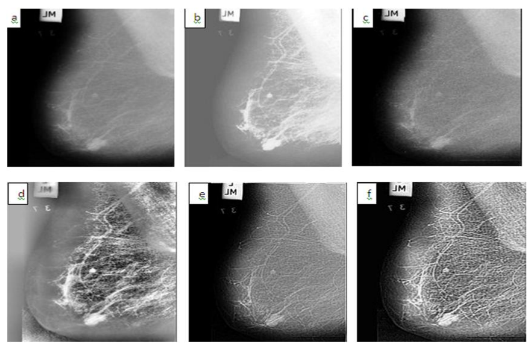

Figure 2.Enhancement results for fatty mammogram image (mdb005) (a) original mammogram image (b) Image Enhancement using Histogram Equalization (c) Image Enhancement using USM (d) Image Enhancement using CLAHE (e) LCM Enhanced Image (f) Proposed method

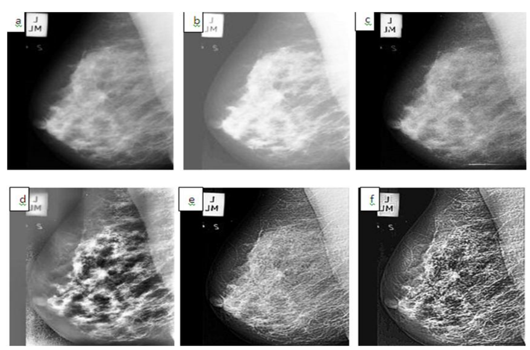

Figure 3 Enhancement Results of Fatty Glandular Mammogram images (mdb219) (a) original image (b) Image Enhancement Using Histogram Equalization (c) Image Enhancement Using USM (d) Image Enhancement Using CLAHE (e) LCM Enhanced Image (f) Proposed Method

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