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Mammographic image enhancement using indirect contrast enhancement techniques – A comparative study

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Abstract

Contrast enhancement is an important issue in the field of mammographic image processing. It can be classified into two categories: direct contrast enhancement and in direct contrast enhancement. Indirect contrast enhancement involves in modifying histogram of the image. Histogram equalization (HE) is the simplest indirect contrast enhancement technique which is widely used for contrast enhancement. Many variants of HE are proposed so far. Comparison of these techniques is significantly essential in deciding a suitable algorithm for enhancement and further processing. In this paper we applied few indirect contrast enhancement techniques namely histogram equalization, CLAHE, BBHE, RMSHE, MMBEBHE to preprocess the mammographic images. The performance of the methods is measured using effective measure of enhancement (EME) and peak signal to noise ratio (PSNR).

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Keywords: Image enhancement; Histogram equalization; CLAHE; BPHE; RMSHE; MMBHE; Effective measure of enhancement;

1 Introduction

Breast cancer is the second leading disease causing death in women, next to lung cancer [24]. Detection and diagnosis of breast cancer in its early stage increases the chances for successful treatment and complete recovery of the patient. Screening mammography has been considered as the reliable imaging system for earlier detection of breast cancer [1]. The subtle signs of cancer such as masses, calcifications are difficult to be detected by the radiologist because mammograms are low contrast [2] which is depicted from Fig.1. Contrast between malignant tissue and normal dense tissue may be present on a mammogram but below the threshold of human perception.

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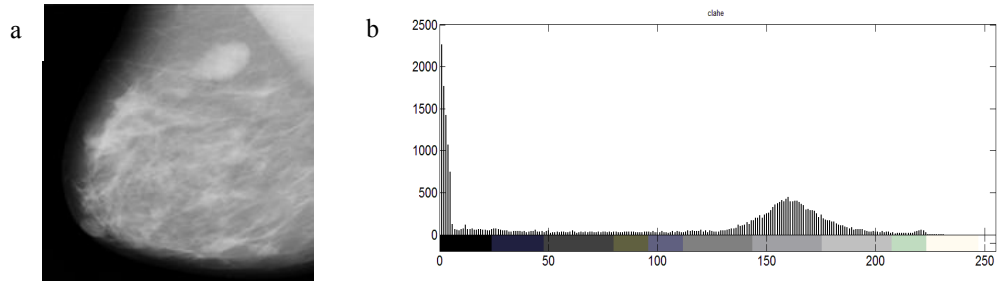

Fig.1. (a) Original mammographic image and (b) its histogram

Hence, the fundamental enhancement needed in mammography is an increase in contrast to enhance image feature against its background to visualize the image properties in an open eye. Various contrast enhancement techniques has been proposed so far [2 - 6, 9 -16].

2 Direct Contrast Enhancement Techniques

Direct contrast enhancement establishes a criterion of contrast measure and enhances the images by improving the contrast directly. Establishment of a suitable image contrast measure is the key step of direct image enhancement.Cheng et al proposed Adaptive fuzzy logic contrast enhancement method which is based on fuzzy entropy principle which transforms the image to a fuzzy domain, and computes the fuzzy entropy and measures the local contrast [3].Rangayyan et al proposed Adaptive neighborhood contrast enhancement technique on measurement of local contrast [4]. In [5], Tang et al, proposed a multiscale local contrast measure in the wavelet domain which enhances the details in different scales. This makes the method suitable for the detection of calcifications that exist in different scales. Yicong Zhou et al suggested HVS based contrast enhancement which separates the abnormal regions without using any thresholding or segmentation algorithm. This feature is useful for automatic detection of breast cancer in the CAD systems [6].

3 Indirect contrast enhancement

Indirect contrast enhancement cannot manipulate the image contrast directly; rather it modifies the histogram of the image and thus increases contrast. Histogram equalization techniques are the popular indirect contrast enhancement methods.

In this paper the general Histogram Equalization (HE), Contrast Limited Adaptive Histogram Equalization(CLAHE), Brightness Preserving Bi-Histogram Equalization (BBHE), Minimum Mean Brightness Error Bi-Histogram Equalization (MMBEBHE), Recursive Mean Separate Histogram Equalization(RMSHE) are analyzed.

3.1 *Histogram Equalization (HE)*

Histogram Equalization [7, 8, 17-20] is a posteriori modelling technique which maps the input gray levels to a gray level proportional to its cumulative density and hence, the probability of each gray level in resulting image is uniformly distributed. The output image histogram should ideally contain an equal number of pixels at every discrete gray level value. The histogram equalization method is global and blind such that it does not take input visual detail in to account while enhancing the image. It results in excessive contrast enhancement, which causes the unnatural look and visual artifacts of the processed image [7].

3.2 *Contrast Limited Adaptive Histogram Equalization (CLAHE*)

CLAHE [7-9, 19-21] is a variant of adaptive histogram equalization. It divides the original image into several non overlapping sub images. Histogram of the sub images are clipped to limit the amount of enhancement of each pixel and then equalized. The details in the image appear clearly relative to the

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