Enhancement in Medical Image Processing for Breast Calcifications and Tumor Detection

1Pouya Derakhshan-Barjoei and 2Mojdeh Bahadorzadeh
1Department of Electrical Engineering, Islamic Azad University, Naein Branch, Naein, Iran
2Department of Surgery, Kashan University of Medical Sciences, Kashan, Iran

Abstract: X-ray image processing is a computerized system which enhances the amount of detail visible on a digitalized x-ray image. The effect of this technique in the diagnoses of breast cancer, where the detection of early malignant tumors is essential for effective treatment, is reviewed in this study. The mammograms, as normally viewed, display a small percentage of the information they detect and that is due to the minor difference in x-ray attenuation between normal glandular tissues and malignant disease. This makes the detection of small malignancies difficult. The digital medical image processing uses denoising and image enhancement techniques so as to reveal any tumors that may not be obvious and help the oncologist decide. The idea is to transform the data into the wavelet basis, in which the large coefficients are mainly the signal and the smaller ones represent the noise. By suitably modifying these coefficients, the noise can be removed from the data. In this study we employ wavelet method of image enhancement and the conclusion would be satisfied.

Key words: Glandular tissue, mammogram, microcalcification, wavelet

INTRODUCTION

Among women, Breast cancer accounts for one third of all cancers detected and 18% of all cancer deaths. Until recently breast cancer was the leading cause of death among women but since 1985 it has ranked second lung cancer. Prevention of this disease is not possible since its cause is not fully understood. However, current methods of treatment are very effective against breast cancer in its early phase (Stamatia Detounis, 2004). Therefore, the most promising way to achieve a change in the current breast cancer situation is to remove the cancer in its early stages. The early detection of breast cancer is most reliably achieved with mammography. However 10 to 30% of women who have breast cancer and who undergo mammography have negative mammograms (Smith, 1993; Holland et al., 1982). In approximately two thirds of these false negative mammograms the radiologist failed to detect the cancer that was evident retrospectively (Ndes and Gallagher, 1982). It is difficult for the human radiologist to maintain interest in interpreting large number of images in which only a small number show abnormalities. Hence the need to construct computer aided systems to diagnose breast cancer in mammograms becomes apparent. Microcalcifications usually come in clusters, having very sharp edges and usually irregular shape of very small size. Due to their high attenuation properties, they appear as white or high intensity spots on mammograms.

There are two goal of this study: Enhancement of mammographic images to achieve better visibility of the observed phenomena to the human observer (radiologist) and processing of mammograms to enable automatic detection of microcalcifications, as a first step to the automated second opinion procedure (Bovik et al., 1987). To achieve both goals, we first use redundant wavelet transform applied to suspicious cutouts of mammograms. Breast calcifications are calcium deposits within breast tissue. They appear as white spots or flecks on a mammogram and are usually so small that you can't feel them. The objective of our study is breast tumor detection, microcalcifications and is important in medical. Breast calcifications can be seen on mammograms performed in most women and are especially prevalent after menopause. Although breast calcifications are usually noncancerous (benign), certain patterns of calcifications such as tight clusters with irregular shapes may indicate breast cancer. On a mammogram, breast calcifications can appear as large white dots or dashes (macrocalcifications) or fine, white specks, similar to grains of salt (microcalcifications). Macrocalcifications are almost always noncancerous and require no further testing or follow up. Microcalcifications are usually noncancerous, but certain patterns can be a sign of cancer. If calcifications are suspicious, further testing may be necessary, including additional mammograms with magnification views or a breast biopsy. While some calcifications may indicate breast cancer, there are many noncancerous (benign) conditions in the breast that can
A modification of median filtering

**Median filtering**

Median filtering is a non-linear digital filtering technique that is often used for noise removal. It is based on the idea of replacing the value at a pixel by the median of neighboring pixels. Median filtering is robust to impulses or outliers, as it is not affected by extreme values in the neighborhood of the pixel. It is used to reduce noise in images, especially in cases where the noise has a significant component, known as impulse noise.

**Selective averaging schemes**

Various modification of median filtering were proposed to improve its performance. Two of these are:

1. **Selection of median filter:** This method involves selecting the median of a window of size and shape that is centered at the pixel of interest. The optimal window size and shape can be determined by minimizing an error criterion.

2. **Edge preservation power of the filter:** This method involves designing a median filter that preserves edges while removing noise. It is achieved by selecting the median of a window of size and shape that is designed to preserve edges.

**Mammograms are initially enhanced by either increasing the contrast of suspicious area or by removing background noise.** Various mathematical methods are then applied to detect the individual tumors depending on whether the tumor appears as a micro calcification cluster or a mass, in mammography the interesting characteristics of an image are malignant masses, microcalcifications and skin thickening of which the last two are said to be indirect signs of malignancy (Abeloff et al., 2008; Adam et al., 2008).

### DETECTION OF MICROCALCIFICATIONS

Currently research is being concentrated on the detection of microcalcifications in mammograms since this is the first indication of the presence of breast cancer. The pre-processing step consists of two main techniques which are used individually or together. The first deals with enhancing the contrast of suspicious area in the image while the second technique involves the removal of background noise from the image. The favored method of image enhancement of mammograms is the removal of background noise while preserving the edge information of suspicious areas in the images. This can be achieved using three different methods:

- **Selective averaging schemes**
- **Median filtering**
- **A modification of median filtering**

**Selection of median filter:** Median filtering has been found to be very powerful in removing noise from 2-D signals without blurring edge (Stamatia Detounis, 2004). This makes it particularly suitable for enhancing images. To apply median filtering to a digital picture, we replace the value at a pixel by the median of the values in a neighborhood of the pixel. Two dimensional median filters can be defined for arbitrary sizes and shapes of filter windows W(i, j), such as line segmenta, squares, circles and crosses. The edge preservation power of the standard median filter is not sufficient for enhancing mammogram images due to the fuzziness of the boundaries of suspicious areas. A modification of the filter selective median filter was defined by (Lai et al., 1989; Rosenfeld and Kak, 1982). The main idea of the median filter is to run through the signal entry by entry, replacing each entry with the median of neighboring entries. The pattern of neighbors is called the "window", which slides, entry by entry, over the entire signal. For 1D signals, the most obvious window is just the first few preceding and following entries, whereas for 2D (or higher-dimensional) signals such as images, more complex window patterns are possible (such as "box" or "cross" patterns). Note that if the window has an odd number of entries, then the median is simple to define: it is just the middle value after all the entries in the window are sorted numerically. For an even number of entries, there is more than one possible median. For a window W (i, j) centered at image coordinates (i, j) the output of the selective median filter is:

$$X_{ij} = \text{Median} \{X_{rs} : (r, s) \in N(I, j) \text{ and } |X_{rs} - X_{ij}| < T\}$$

where (i, j) \in Z^2, N (i, j) is the area in the image covered by window W (i, j) and T is a threshold.

**Wavelet expansion and techniques:** (John et al., 1997) developed a method for identifying clinically normal tissue in digitized mammograms is used to construct an algorithm for separating normal regions that may contain isolated calcifications. Research into the detection of microcalcifications using primary wavelet transform has been carried out by and parkin, McLeod (1996).

This technique was designed to replace the FFT (Fast Fourier Transform) method as it was found to be simpler and more efficient. The first step is to decompose the image with a wavelet expansion that yields a sum of independent images, each containing different levels of image detail. A Fast Fourier Transform (FFT) is an efficient algorithm to compute the Discrete Fourier Transform (DFT) and its inverse. An FFT computes the DFT and produces exactly the same result as evaluating the DFT definition directly; the only difference is that an FFT is much faster. The DFT is defined by the formula:

$$X_k = \sum_{n=0}^{N-1} x_n e^{-i2\pi \frac{k n}{N}} \quad k = 0, \ldots, N - 1$$

This decomposition is repeated to further increase the frequency resolution an the approximation coefficients decomposed with high and low pass filters and then down-sampled. This is represented as a binary tree with nodes representing a sub-space with a different time-frequency localisation.

When calcifications are present, there is strong empirical evidence that only some of the image components are necessary for detecting a deviation from
Fig. 1: A 3 level filter bank

normal. (Ted and Nicolas, 1998), presented an approach for detecting microcalcifications in digital mammograms employing wavelet based sub band image decomposition. A three level filter bank is shown in Fig. 1. The microcalcifications appear in small clusters of few pixels with relatively high intensity compared with their neighboring pixels. These image features can be preserved by a detection system that employs a suitable image transform which can localize the signal characteristic in the original and the transform domain. The sequence of N complex numbers $x_0, ..., x_{N-1}$ is transformed into the sequence of N complex numbers $X_0, ..., X_{N-1}$ by the DFT according to the formula:

$$X_k = \sum_{n=0}^{N-1} x_n e^{-2\pi i kn/N} \quad k = 0, ..., N - 1$$

where $i$ is the imaginary unit and $e^{-2\pi i/N}$ is a primitive $N$th root of unity.

It is computationally impossible to analyze a signal using all wavelet coefficients, so one may wonder if it is sufficient to pick a discrete subset of the upper halfplane to be able to reconstruct a signal from the corresponding wavelet coefficients. One such system is the affine system for some real parameters $a>1$, $b>0$. The corresponding discrete subset of the halfplane consists of all the points $(a^m, n a^n b)$ with integers $m, n \in \mathbb{Z}$. The corresponding baby wavelets are now given as:

$$\psi_{m,n}(t) = a^{-m/2} \psi(a^{-m}t - nb).$$

A sufficient condition for the reconstruction of any signal $x$ of finite energy by the formula:

$$s(t) = \sum_{n \in \mathbb{Z}} \sum_{m \in \mathbb{Z}} (x, \psi_{m,n}) \psi_{m,n}(t)$$

is that the functions $\{\psi_{m,n} : m, n \in \mathbb{Z}\}$ form a tight frame of $L^p$ function space $L^2(R)$. This subspace in turn is in most situations generated by the shifts of one generating function $\psi \in L^2(R)$:

$$\psi(t) = 2 \sin(2t) - \sin(t) = \frac{\sin(2\pi t) - \sin(\pi t)}{\pi}$$

with the (normalized) sinc function.

**PROPOSED METHODS AND RESULTS**

Wavelet theory provides a powerful framework for multiresolution analysis and it can be used for texture analysis. This study can help physicians to improve the minimal invasive operation for a breast tumor. Typical experiment about breast region segmentation is shown in Fig. 2. (Michael and Alexei, 2004).

Our proposed method using Wavelet decomposition for two times the result of frequency components of mammogram image is shown in Fig. 3 and Fig. 4.

For a mammogram processed with our method at different levels of wavelet analysis, the final image of component yielding as shown in Fig. 5.

Our original mammogram image and final result of our method as described is shown in Fig. 6. We can compare them and see how the microcalcification detection in clear, so the threshold setup and noise reduction for each image should be set intelligently.

In medical images, noise suppression is a particularly delicate and difficult task. A tradeoff between noise reduction and the preservation of actual image features has to be made in a way that enhances the diagnostically relevant image content. We evaluate two-dimensional denoising procedures using medical test images corrupted with additive Gaussian noise. Our results, using the peak-signal-to-noise ratio as a measure of the quality of denoising, show that the proposed method outperforms well.
Fig. 2: (a) Original mammogram; (b) Enhanced image; (c) Extracted breast region; (d) Contour overlain on a LOG-attenuated version of (a); (e) Micro calcification in breast; (f) White specks

Fig. 3: Four images of the first step of decomposition from original mammogram image

Fig. 4: Four images of the second step of decomposition from mammogram image
Fig. 5: Image of final composition of the levels

Fig. 6: (a) Original mammogram image; (b) Microcalcification detected image of our method

CONCLUSION

In our method a digital medical image processing uses denoising and image enhancement techniques to reveal any tumors that may not be obvious. The method of wavelet thresholding has been used extensively for denoising medical images. The idea is to transform the data into the wavelet basis, in which the large coefficients are mainly the signal and the smaller ones represent the noise. By suitably modifying these coefficients, the noise can be removed from the data. We employ wavelet method of image enhancement and the results show good performance. The proposed technique in the diagnoses of breast cancer enhanced by either increasing the contrast of suspicious area or by removing background noise. The method of wavelet thresholding, mathematical method, is applied to detect the individual tumors depending on whether the tumor appears as a microcalcification cluster or a mass, in mammography the interesting characteristics of an image are malignant masses, microcalcifications and skin thickening of which the last two are said to be indirect signs of malignancy.

REFERENCES


