Wavelet Based Microcalcification Detection On Mammographic Images

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Summary
This paper uses the spatial decomposition property of the discrete wavelet transform and statistical analysis in the property of skewness and kurtosis in order to trace out Microcalcification in the mammographic images. The mammographic images are region grown and applied with the wavelet transform .The spatial decomposed image that was got from the wavelet transform is subjected to statistical analysis. This statistical analysis involves finding skewness and kurtosis on the spatial coordinates of the decomposed image. This statistical analysis removes the complexity of edge detection techniques. And this becomes a pure numerical and probabilistic approach of finding the malign and benign microcalcification .The false acceptance ratio was found to be 4%. Image processing toolbox in Matlab is used for this application development.

Keywords:
Microcalcification, DWT, Skewness, texture, breast and Kurtosis.

1. Introduction

Women suffering from Breast cancer have been taken as a serious concern all around the world, As it directly affects the next generation to come. Mammography has become a major field in medical diagnostics as there are one out of eight women affected by breast cancer. Constant Mammographic screening programs for women of a particular age group are taking place worldwide. In the developing and the developed world breast has become the major threat for the lives of the women. WHO (World Health Organization) estimates that nearly 2, 00,000 women worldwide die of breast cancer each year. Breast cancer is one among the top three cancers in World involving women. In United States, the American Cancer Society estimates that, 215 990 new cases of breast cancer has been diagnosed. It is the leading cause of death due to cancer in women under the age of 65. In India, breast cancer accounts for 23% of all the female cancers followed by cervical cancers (17.5%) in metropolitan cities such as Mumbai, Calcutta, and Bangalore [1]. For detecting the Breast cancer a high quality image is required. Clinicians who diagnose the microcalcification must be trained very well in order to attain the correct diagnosis. Detected Macro-calcifications will be often benign (not cancer).

The benign Micro-calcification will be large and round in the mammograph. Smaller and more numerous than the larger macro-calcifications will also be present as a microcalcification. They seldom will be detected as the cancer complaint. The radiologist will look at the size, shape and distribution of the micro-calcifications to see if they are suspicious. An ultrasound study and a biopsy and lot of mammograms may be necessary. Suspicious micro-calcifications turn out to be cancer about 20 to 25 percent of the time.

In this paper, we have proposed a new method in which digitized mammograms are decomposed using wavelet transform filter bank without down sampling process at several levels in the transform space (detailed and smooth subbands). In order to achieve high resolution of wavelet transform subband coefficients, multiscale adaptive gain is then applied as an enhancement technique. These subband coefficient are processed to detect the availability of microcalcification, by using the statistical algorithm i.e., skewness and kurtosis method. Since microcalcification are small isolated regions in mammograms, The detail-image is first divided into overlapping square regions in which skewness and kurtosis are measures of the asymmetry and impulsiveness of the distribution are estimated. A region with high positive skewness and kurtosis is marked as a region of interest (ROI) the microcalcification in the susceptible regions.

It is very hard to diagnose whether it is a cancer or not. They are called In determinates. When this happens the clinicians may take more X-rays to help decide if the micro-calcifications are benign, probably benign, suspicious, or malignant. If they are probably benign, then there is a 98 percent chance that they are not cancer. However, if they are suspicious, more follow-up is needed.

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2. Implementation

The microcalcification detection algorithm were proposed by using statistical methods such as skewness, kurtosis and boxplot outlier. Detection methods were applied on modification decomposed image as a sum result of matrixes on detail component orientation (horizontal, vertical and diagonal). In this paper, detection is carried out in two steps. First, the detail-image is divided into same square region size, i.e. ***n*** x ***n*** pixels.

2.1. Wavelet Decomposition

The DWT of a signal *x* is calculated by passing it through a series of filters. First the samples are passed through a low pass filter with impulse response *g* resulting in a convolution of the two:
The wavelet transform is defined as [4],

$$WT f(x) = \frac{1}{\sqrt{a}} \int f(x) \Psi\left(\frac{x-b}{a}\right) dx \qquad (1)$$

This transform can be seen as a mathematical microscope whose position zooms on location ***b*** with a magnification 1/a and whose optical characteristics is described by the mother wavelet **.**

The signal is also decomposed simultaneously using a high-pass filter *h*. The outputs giving the detailed coefficients (from the high-pass filter) and approximation coefficients (from the low-pass). It is important that the two filters are related to each other and they are known as a quadrature mirror filter.

However, since half the frequencies of the signal have now been removed, half the samples can be discarded according to Nyquist's rule. The filter outputs are then down sampled by 2 (It should be noted that Mallat's and the common notation is the opposite, g- high pass and h- low pass)

It has been shown that the dilations and translations [4][5],of a mother wavelet
can be used as an orthonormal basis for the multiresolution decomposition of signals into octave subbands (by means of dilation) with an excellent spatial location property (by means of translation). The translation index ***k*** is measured in terms of the wavelet's support width. In multiresolution

$$\Psi_{jk}(x) = 2^{-j/2}\Psi(2^{-j} x-k)(j,k) \in Z^2 \qquad (2)$$

analysis, one also defines the dilations and translations of the lowpass filtering or scaling function defined as

$$\Phi_{jk}(x) = 2^{-j/2}\, \Phi(2^{-j} x-k),\ (j,k) \in Z^2 \qquad (3)$$

The wavelet transform of a given signal may be interpreted as the decomposition of the signal into a set of time frequency functions by the use of translated and dilated basis functions of a mother wavelet, i.e.,

$$f(x) = \sum_{j=1}^{f} \sum_k d_{jk}\Psi_{jk}(x) + \sum_k S_{jk}\Phi_{jk}(x) \qquad (4)$$

where j is maximum level of decomposition.

3. Classification

Skewness: Skewness, the third standardized moment, is written as γ_1 and defined as $\gamma_1 = \mu_3/\sigma^3$ where μ_3 is the third moment about the mean and σ is the standard deviation. Equivalently, skewness can be defined as the ratio of the third cumulate κ_3 and the third power of the square root of the second cumulant .This is analogous to the definition of kurtosis, which is expressed as the fourth cumulant divided by the fourth power of the square root of the second cumulant.

4. Microcalcification Detection

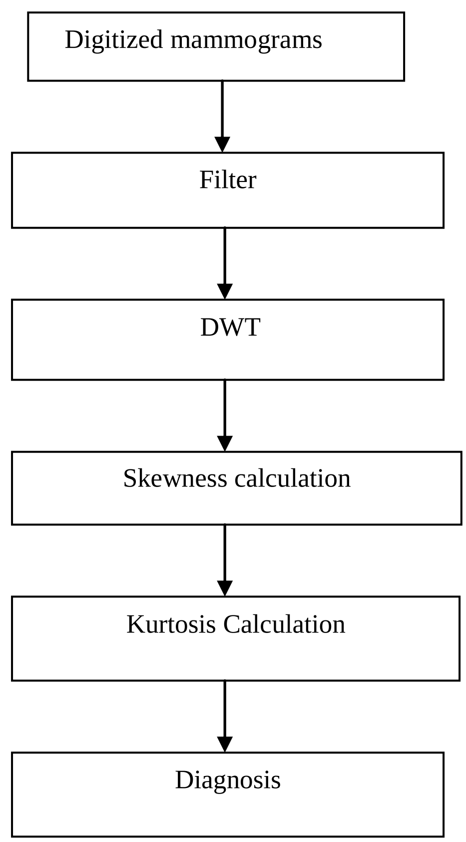

Fig. 8. Flowchart of Microcalcification detection

For a sample of n values the *sample skewness* is

$$g1 = \frac{k_3}{k_2^{3/2}}$$

$$g1 = \frac{\sqrt{n \sum_{i=1}^{n} (x_i - x)}^{\;3}}{\left(\sum_{i=1}^{n} (x_i - x)^{2}\right)^{3/2}}$$

where X_i is the i^{th} value, X is the sample mean, m_3 is the sample third central moment, and m_2 is the sample variance. Given samples from a population, the equation for the sample skewness g_1 above is a biased estimator of the population skewness. The usual estimator of skewness is

$$G1 = \frac{k}{k_2^{3/2}}$$

$$G1 = \frac{\sqrt{n(n-1)g_1}}{n-2}$$

where k_3 is the unique symmetric unbiased estimator of the third cumulant and k_2 is the symmetric unbiased estimator of the second cumulant. Unfortunately G_1 is, nevertheless, generally biased. Its expected value can even have the opposite sign from the true skewness.

The skewness of a random variable X is sometimes denoted Skew[X]. If Y is the sum of n independent random variables, all with the same distribution as X, then it can be shown that Skew[Y] = Skew[X] / $\sqrt{n}$.

Skewness has benefits in many areas. Many simplistic models assume normal distribution i.e. data is symmetric about the mean. The normal distribution has a skewness of zero. But in reality, data points are not perfectly symmetric. So, an understanding of the skewness of the dataset indicates whether deviations from the mean are going to be positive or negative

4.1. Kurtosis:

In real applications, any signals can be classied as having a stationary or a non stationary behavior. Same is the state in the image. Stationary signals will show statistical properties that remain unchanged with the changes with time.

A statistical test based on skewness and kurtosis is effective in finding regions with asymmetrical and heavier tailed distributions [3].

Kurtosis, The fourth standardized moment is defined as

$$\frac{\mu_4}{\sigma^4}$$

where μ_4 is the fourth moment about the mean and σ is the standard deviation. This is sometimes used as the definition of kurtosis in older works, but is not the definition used here.

Kurtosis is more commonly defined as the fourth cumulate divided by the square of the variance of the probability distribution,

$$\gamma_1 = \frac{k_4}{k_2^2}$$

$$\gamma_2 = \frac{\mu_4}{\sigma^4 - 3}$$

which is known as excess kurtosis. The "minus 3" at the end of this formula is often explained as a correction to make the kurtosis of the normal distribution equal to zero. Another reason can be seen by looking at the formula for the kurtosis of the sum of random variables. Because of the use of the cumulant, if Y is the sum of n independent random variables, all with the same distribution as X, then Kurt[Y] = Kurt[X] / n, while the formula would be more complicated if kurtosis were defined as μ_4 / σ^4.

More generally, if X_1, ..., X_n are independent random variables all having the same variance, then

$$Kurt\left(\sum_{i=1}^{n} X_i\right) = \frac{1}{n^2}\sum_{i=1}^{n} \mathrm{Kurt}(X_i)$$

Whereas this identity would not hold if the definition did not include the subtraction of 3.The fourth standardized moment must be at least 1, so the excess kurtosis must be −2 or more; there is no upper limit and it may be infinite

The simulation is carried out by using the following conditions :

1.Test mammogram images were obtained by scanned as raw format with 8-bit grayscale and 256x256 pixels size. These mammograms have been chosen by the radiologist and suspected as mammograms with microcalcification. In this simulation, 30 variation of image as part of 18 digitized mammograms is used.

2.The chosen wavelet basis function is the Haar with four coefficients as a filter banks. These processes were applied without 2-factor down sampling from wavelet transform coefficients. Its used to reduce lost information and maintain size of images.
3.Global image enhancement procedure was applied only on 4-level decomposed detail subband image (highpass components) usin g multiscale adaptive gain method. In this technique, highpass components will be suppressed if it's value less than the threshold and will be increased if it's greater than threshold.
4.The detection of microcalcification algorithm will be done as described above.

5. Results and discussion

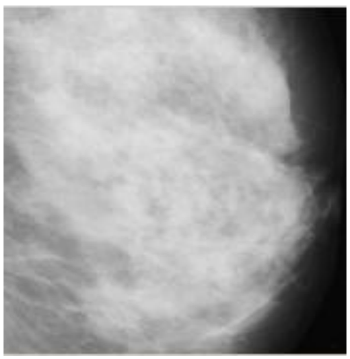

Fig.1. Raw image

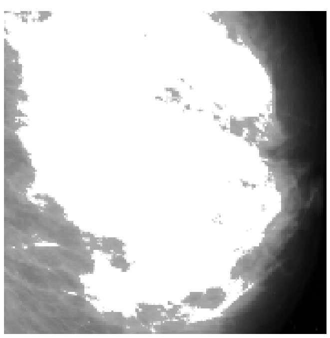

Fig.2. DWT image

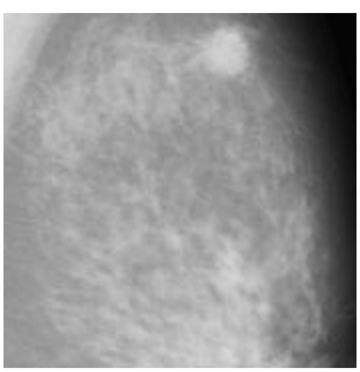

Fig.3. Raw image

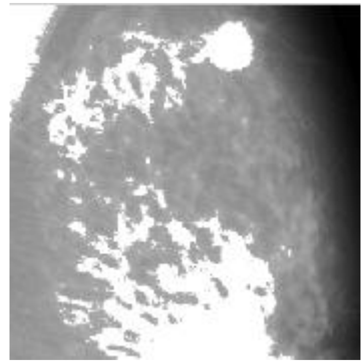

Fig.4. DWT image

The Fig.1 image is the original image and the latter Fig.2 is the discrete wavelet transformed image .This particular image was not detected with the microcalcification .The Fig.3 is the original image and the wavelet transformed image of theat image is given in the Fig.4 and this image was found to have the microcalcification detected.

The described method has been tested on many mammographic images taken from the Digital Database for Screening Mammography (DDSM). The primary purpose of this database is to facilitate a sound research in the development of computer algorithms to aid in screening.

In particular, all the microcalcifications identified by the specialists in the database (many of them classified with a very high subtlety rating) have been correctly enhanced by the algorithm without the introduction of any artifact, allowing a more simple detection by the radiologist with respect to the plain image or the image processed by standard algorithms.

Fig. 1 shows the region of interest (ROI) of an original dense mammographic image with a microcalcification lesion

Conclusion

In this paper automatic detection of microcalcification in mammogram images are considered. In this method the mammogram images are first processed by a subband decomposition filter bank. The bandpass subimages is divided into overlapping square regions, in which skewness and kurtosis are the measures of the asymmetry and impulsiveness of the distributions are estimated. The detection method utilizes these two parameters. A region with high positive skewness and kurtosis is marked as region of interest. Based on the simulation results, the final results indicated visually that applied detecting method has succeeded 96% in an effectiveness level. The regions of clustered microcalcification can be detected and the presence another location of clustered microcalcification could be considered to clarify the diagnoses. In order to test the detection method, we used the visual analysis to detect presence microcalcification in mammograms based on comparison between the result images and the original ones. The result of test images shown effectiveness simulation on microcalcification detection, even there are some result could not detect the clustered microcalcification. Fail of detection process will reduce the calculation of Simulation effectiveness. From the 50 test images, there were the 48 test images result a good detection process and just two images failed. Additionally the processing is simple and does not require a full decomposition and reconstruction.

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