

Comparison of Microcalcifications Detection in Digital Mammograms Using Undecimated Filter Banks

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Abstract: - This paper presents the comparisons of five different undecimated filter banks used for microcalcifications detection. The microcalcifications appear as a small number of high intensity pixels compared with their neighbors. As microcalcifications are high frequency signals, detection can be carried out by decomposing the image in several frequency subbands and discarding the subband that carries the lowest frequencies (smooth signals). The reconstruction of the image contains only details of high frequencies. The results obtained show that there is no a substantial difference in the number of detected microcalcification among the several filter banks.

Key-Words: - Breast cancer, Microcalcifications Detection, Undecimated filter bank.

1 Introduction

Breast cancer is a disease where abnormal cells grow in an uncontrolled fashion and is the most common cause of death in middle age-women [1]. Early detection plays a very important role in cancer treatment and allows a faster recovery for most of the patients.

Screen films are considered the most reliable method for breast cancer detection. However, mammograms provided by the X-ray equipment, are very difficult to interpret. The early detection, through this method, is still a challenge for the radiologists. Automatic systems help the radiologist to give a more accurate diagnostic [2].

Breast abnormalities are divided into exhibiting microcalcification, circumscribed lesions and speculated lesions. One of the earliest signs of breast cancer is the formation of clusters of microcalcifications.

Microcalcifications are tinny specs of calcium in the breast and only can be detected on a mammogram. These deposits of calcium are very small spots of high contrast, inside the mammogram. Microcalcifications are related to breast cancer

because 30% to 50% of malignant breast tumors are surrounded by microcalcifications [3].

Approximately from 10% to 30% of breast cancer is missed by the radiologists because, microcalcifications are difficult to detect in a simple sight [4].

Wavelets have been widely used in the medical imaging field, since any area or areas of an image can be enhanced easily by amplifying them or by modifying the wavelet coefficients. In other words, wavelets use basis functions that can dilate in scale and translate in position according to the signal characteristics [4], [5], [6].

Wavelet transforms are implemented by using filter banks. Two stages are used; one to decompose the signal (analysis) and one to recover the signal (synthesis). Synthesis bank must invert the analysis bank in order to have perfect reconstruction of the signal at the output of the filter bank. The simple filter bank has the analysis filters preceded by downsamplers and the synthesis filters followed by upsamplers.

Downsampling operation introduces aliasing and is not removed completely by the analysis filters as the filters are not ideal. Downsampling-upsampling operations are used to avoid the oversampling

problem in signal compression applications. However, these operations can be removed and still have perfect reconstruction of the signal without aliasing introducing aliasing in the analysis stage. On the other hand, the number of samples per dimension of signal is doubled at the output of the analysis bank. This type of scheme is known as undecimated filter bank and is described in Fig. 1.

This paper is organized as follows: Section 2 presents the methodology of the implementation. The results and conclusions are presented in Section 3 and 4 respectively.

2 Methodology

This section reviews the process to detect microcalcifications, in digital mammograms, using five undecimated filter banks.

2.1 Image segmentation

A Sobel filter was applied on the image to detect the edges of the region of interest (ROI). The ROI is the breast of the digital mammogram and the goal is to isolate this area from the film. A dilation operation was performed after filtering to connect edges.

Dilation was followed by filling the remaining holes of the ROI. This process produced a mask of ones in those pixels engulfed by the ROI. A multiplication of the mask with the digital mammogram was carried out to segment the breast area (\mathcal{X}) which is the input to the filter bank.

2.2 Decomposition and reconstruction of the image

Consider the 2D two-channel filter bank shown in Fig. 1. Filters $h1(n)$ and $h2(n)$ are low pass filters and $g1(n)$ and $g2(n)$ are high pass filters; $h1(n)$ and $g1(n)$ are at the analysis section and are used to decompose the input image (\mathcal{X}) in frequency subbands; $h2(n)$ and $g2(n)$ are the synthesis bank and invert the analysis operation in order to produce a perfect reconstruction of the input image ($\mathcal{X} = \hat{\mathcal{X}}$) [7], [8], [9].

All filters in the filter bank are separable. Filtering of \mathcal{X} along rows is followed by filtering along columns. At the output of the analysis stage the Low-Low (LL), Low-High (LH), High-Low (HL) and High-High (HH) subbands are obtained. Since we are using undecimated filter banks, each subband is approximately the same size as the input image. The LL subband contains only smooth information and can be discarded (set to zero all coefficients) given that microcalcifications

correspond to high frequency components [10]. This process can be seen as a segmentation process for microcalcifications.

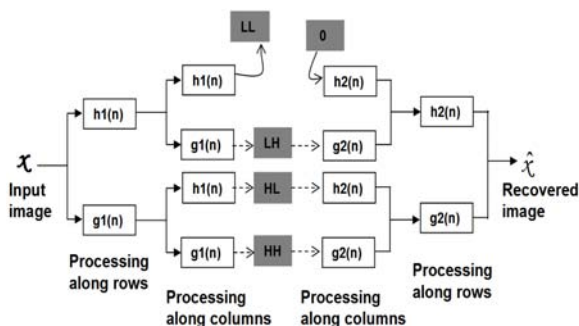


Fig. 1. 2-D two-channel undecimated filter bank.

After zeroing the LL subband, the image is recovered by applying the remaining subbands to the synthesis bank as depicted in Fig. 1. The inverse process includes filtering along columns followed by filtering along rows.

2.3 Image thresholding and microcalcification area enhancement

At the output of the synthesis bank a noisy image ($\hat{\mathcal{X}}$) is recovered. However, most of the microcalcifications are of greater magnitude than the noise. Therefore, thresholding was applied to the recovered image, in order to remove noise. After exhaustive tests, on test images, a threshold of ± 17 was found.

The recovered images were analyzed in sets of 2×2 neighbor samples. If one of the samples, in the set, is greater than the threshold, the set contains a microcalcification. Therefore, all the neighbor samples are set to a maximum value of 255. The images were inverted, in order to show the detected microcalcifications.

3 Tests and Results

The results presented in this paper correspond to digital mammograms different from those used to determine the threshold.

All the tests were carried out using digital mammograms from the Mammographic Image Analysis Society (MIAS) databases [11]. Each image is of 1024×1024 pixels, 8 bits gray depth. The selected mammograms are medio-lateral oblique view, from 31 patients and digitized with spatial resolution of 50 mm. The images were previously investigated and labeled by an expert radiologist based on a technical experience and a biopsy. From the 31 mammograms processed, that

contain microcalcifications, three of them were selected randomly to be presented in this paper.

A microcalcification shape is shown in Fig. 2. The amplitude is high, as compared to the rest of the samples, and its duration is short (only some samples). The microcalcifications more difficult to observe are those that are supported for less samples.

We used 5 different filter pairs: v9/3, Coiflet Daubechies Filter 9/7, Legal, Daubechies 2db2, Daubechies 4db4. Fig. 3 shows the mdb219 and output images (detected microcalcifications), after processing with the filters mentioned above.

The Fig. 4 shows the results obtained with the image mdb023 and the same filters. Finally, Fig. 5 shows the image mdb245 and the results obtained.

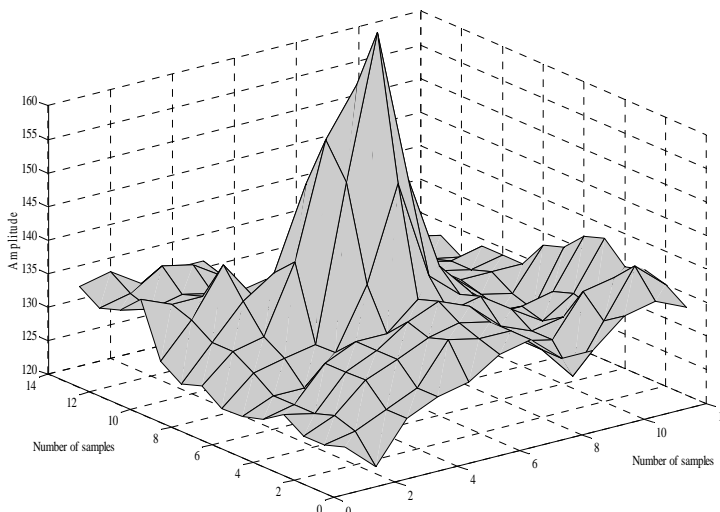


Fig. 2. The shape of a microcalcification.

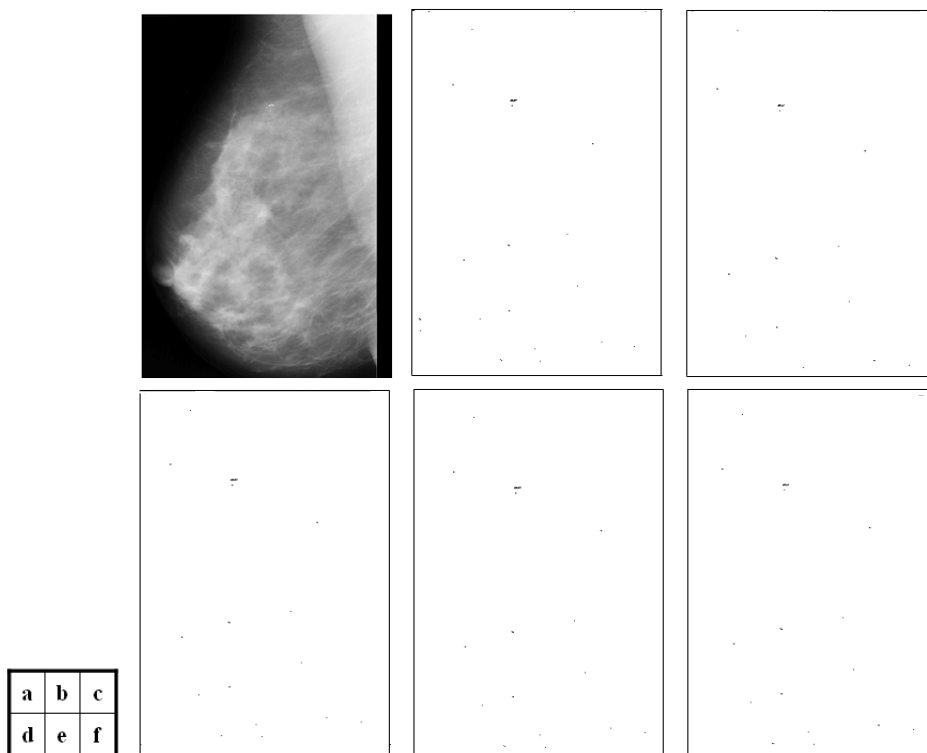


Fig. 3. a)Original image mdb219 and recovered images using the filters b) V9/3, c) CDF9/7, d) Le Gal 5/3, e) Daubechies 2 and f) Daubechies 4.

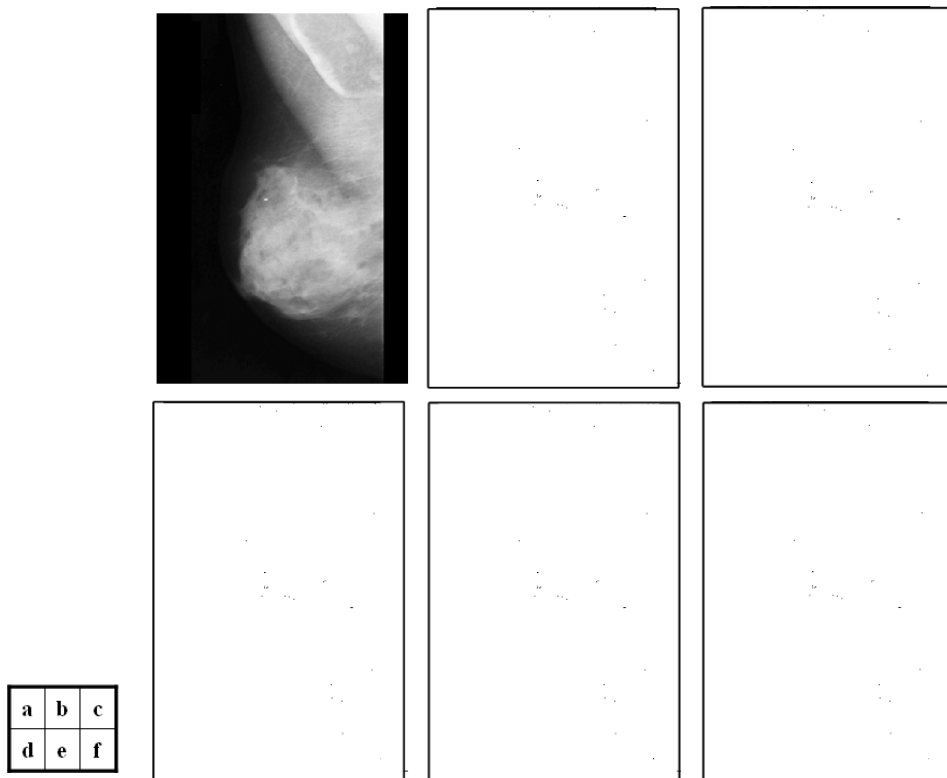


Fig. 4. a) Original image mdb223 and recovered images using the filters b) V9/3, c) CDF9/7, d) Le Gal 5/3, e) Daubechies 2 and f) Daubechies 4.

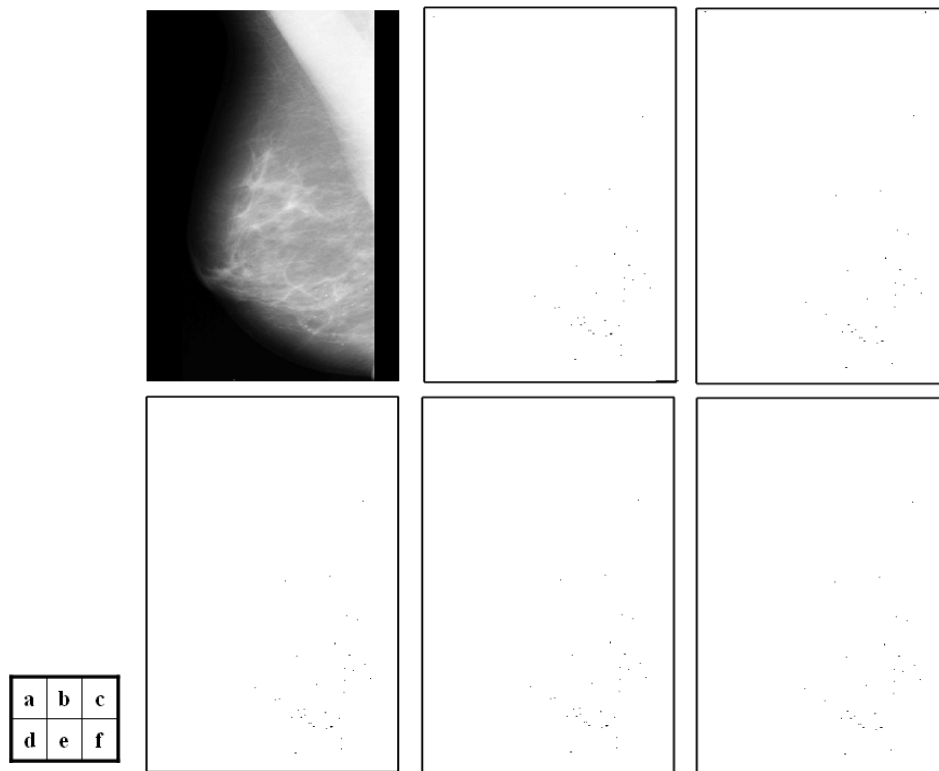


Fig. 5. a) Original image mdb245 and recovered images using the filters b) V9/3, c) CDF9/7, d) Le Gal 5/3, e) Daubechies 2 and f) Daubechies 4.

4 Conclusion

In this paper the comparisons of microcalcifications detection using five different undecimated filter banks were presented. The test images were selected randomly. Figures 3 to 5 show no substantial changes in the detection of microcalcification with the method used. All of the implemented banks miss some microcalcifications, especially those with the smallest support in samples, what suggest that microcalcifications need to be modeled more accurately.

More work need to be done with techniques that allow us to determine when a microcalcification is benignant or malignant.

References:

- [1] Verma B. and Zhang P., A Novel Neural-Genetic Algorithm to Find the most Significant Combination of Features in Digital Mammograms, *Applied Soft Computing*, vol. 7, no. 2, pp. 612 – 625, March 2007.
- [2] Essam A., Rashed E. A., Ismail A., Ismail B. and Sherif I., Multiresolution Mammogram Analysis in Multilevel Decomposition, *Pattern Recognition Letters*, vol. 28, no. 2, pp. 286 – 292, January 2007.
- [3] Sickles A. E., Mammographic Features of Early Breast Cancer, *American Journal of Roentgenology*, vol. 143, no. 3, pp. 461 – 464, May 1984.
- [4] Bird R. E., Wallace T. W. and Yankaskas B. C., Analysis of Cancers Missed at Screening Mammography, *Radiology*, vol. 184, pp. 613 – 617, 1992.
- [5] Al-Qdaha M., Rahman Ramlib A. and Mahmudc R., A System of Microcalcifications Detection and Evaluation of the Radiologist: Comparative Study of the Three Main Races in Malaysia, *Computers in Biology and Medicine*, vol. 35, no.10, pp. 905 – 914, December 2005.
- [6] Wang T. C. and Karayiannis N. B., Detection of Microcalcifications in Digital Mammograms Using Wavelets, *IEEE Transactions on Medical Imaging*, vol. 17, no. 4, pp. 498 - 509, August 1998.
- [7] Strang G. and Nguyen T., *Wavelets and Filter Banks*, Wesley Cambridge Press, 1997.
- [8] Bopardikar A., Raghuvveer M. and Adiga B., Perfect Reconstruction Circular Convolution Filter Banks and their Application to the Implementaion of Bandlimited Discrete Wavelet Transforms, *IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP)*, vol. 5, pp.3665, April 1997.
- [9] Vetterli M., Filter Banks Allowing Perfect Reconstruction, *Signal Processing*, vol. 10, no. 3, pp. 219 - 244, April 1986.
- [10] Yu S. N., Li K. Y. and Huang Y. K., Detection of Microcalcifications in Digital mammograms Using Wavelet Filter and Markov Random Field Model, *Computerized Medical Imaging and Graphics*, vol. 30, no. 3, pp. 163-173, April 2006.
- [11] Suckling J., Parker J., Dance D. Astley S., Hutt I., Boggis C., Ricketts I., Stamatakis E., Cerneaz N., Kok S., Taylor P., Betal D. and Svage J., The Mammographic Image Analysis Society Digital Mammogram Database, *Exerpta Medica, International Congress Series 1069*, pp. 375 – 378, 1994.