# SHORT NOTE

# MORPHOLOGICAL TECHNIQUES FOR MICROCALCIFICATION AND MASS ENHANCEMENT

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## ABSTRACT

*The recognition of microcalcifications and masses from digital mammographic images are important to aid the detection of breast cancer. In this paper, we applied morphological techniques to extract the embedded structures from the images for subsequent analysis. A mammographic phantom was created with embedded structures such as micronodules, nodules and fibrils. For the preprocessing techniques, intensity transformation of gray scale was applied to the image. The structures of the image were enhanced and segmented using dilation for a morphological operation with morphological closing. Next, low pass Gaussian filter was applied to the image to smooth and reduce noises. It was found that our method improved the detection of microcalcifications and masses with high Peak Signal To Noise Ratio(PSNR).*

## ABSTRAK

*Pengecaman mikrokalsifikasi dan gumpalan dalam imej mammografi digital adalah penting untuk membantu pengesanan kanser payudara yang pra-matang. Dalam kertas ini, kami menggunakan teknik morfologi untuk mengeluarkan struktur yang tertanam dalam imej untuk analisis berikutnya. Fantom mammografi diciptakan dengan struktur yang tertanam seperti micronodul, nodul dan gentian halus. Bagi teknik pra pemprosesan, transformasi keamatan skala kelabu telah digunakan untuk imej. Struktur imej dipertingkatkan dan disegmentasikan menggunakan kaedah dilasi untuk operasi morfologi dengan penutupan morfologi. Penuras lepas rendah Gaussian telah digunakan untuk imej untuk melicinkan dan mengurangkan hingar selepas segmentasi. Kaedah kami memperbaiki pengesanan mikrokalsifikasi dan gumpalan dengan nilai PSNR yang tinggi.*

***Keywords*** Microcalcifications, Masses, Morphological Techniques, Dilation, Morphological Closing, Low Pass Gaussian filter

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# INTRODUCTION

In the female population around the world, breast cancer is the leading cause of cancer mortality among most middle-aged women. Early detection and treatment of breast cancer are the most effective methods to reduce mortality. Mammography has proven to be the most effective tool for detecting breast cancer in early stage.

Masses and microcalcifications are the most common abnormalities which indicate to breast cancer. Most mammographic images are very difficult to interpret by radiologists because most images are usually noisy and have low contrast due to high density breast structures. The interpretation of the mammograms by the radiologists give high rates of false positive cases.

Mohideen et al (2011) proposed a multiwavelet method for noise suppression and enhancement in digital mammographic images. They preprocessed the images to enhance the local contrast in dense regions adaptively. They compared the wavelet and multiwavelet techniques based on the performance of image denoising algorithms in terms of PSNR values. The method had improved structures in low contrast image regions.

Papadopoulos et al (2008) proposed five microcalcifications enhancement as a preprocessing module in Computer Aided Detection (CAD) system. They had tested five image enhancement algorithms introducing the Contrast Limited Adaptive Histogram Equalization (CLAHE), the local range modification (LRM), the redundant discrete wavelet (RDW), linear stretching and shrinkage algorithms. Those techniques were evaluated by using Receiver Operating Characteristic (ROC) analysis of CAD system. Two mammographic datasets from the LRM method performed the highest area under ROC curve ($A_z$).

Panda et al (2009) presented a research based on three step procedure including regions of interest (ROI) specification, two dimensional wavelet transformation and feature extraction based on OTSU thresholding the regions of interest for the identification of microcalcifications and mass lesions. ROIs were preprocessed using a wavelet-based transformation method and a thresholding technique was applied to exclude microcalcifications and mass lesions. Those method could enhance diagnostic performance and improved interpretation by radiologists.

Diekmann et al (2001) presented a method to visualize microcalcifications from Full Field Digital Mammography using wavelet frames, an enhancement operator and reconstruction technique. The means of a filter bank algorithms which based on wavelet decomposition highlighted the structures of microcalcification. This method was adjusted to overcome the problem of image analysis for better discrimination of microcalcifications from the image background. They compared the method using unsharp-mask filtering and wavelet procedure. They found that wavelet procedure could improve the detection of microcalcifications by highlighted objects with wide size range.

Nien Yu et al (2006) proposed a two stage method to detect microcalcifications. Wavelet filter by thresholding a filtered mammogram was applied to identify suspicious microcalcifications according to the mean pixel value from the images. Features based on a Markov Random Field (MRF) model were extracted from the neighborhood on every suspicious microcalcifications. Three auxiliary texture quantities were extracted from the neighborhood as inputs to Bayes classifier and back propagation neural network. The sensitivity is 92% with only 0.75 false positives per image. They found that suitable classifier and the texture feature based on Markov Random Field parameters with designed auxiliary features extracted from the texture context of the microcalcifications could work properly.

Alfonso and Asoke (2008) proposed an enhancement algorithms based on local statically measures of the mammograms which improved image contrast. Regions were segmented using multiple levels thresholding and set of features were computed from each of the segmented regions after enhancement. Their method achieved 80% per image sensitivity and had detected at 2.37 false positives per image. However, a large number of regions must be processed which result in high cost of resources and computing time.

In this paper, morphological techniques were applied for microcalcifications and masses enhancement in the mammographic image in order to extract the embedded structures for subsequent analysis. A mammographic phantom was created with embedded structures of micronodules, nodules and fibrils for image evaluation. Intensity transformationof the grey scale was applied to the images as a preprocessing method to adjust the image intensity. Next, dilation for a morphological operation and morphological closing were applied for segmentation. After segmentation, the image was smoothed and denoised by using low pass Gaussian filter. The performance of the image will be evaluated using Mean Squared Value (MSE) and Peak Signal To Noise Ratio (PSNR).

## METHOD DESCRIPTION

### *Theoretical Background*

### Gray-Scale Dilation

Dilation is the morphological transformation which combines two sets using vector addition of set elements (Haralick et al, 1987). Dilation was applied as smoothing operations in many studies of image processing.
Gray scale dilation of $f$ by structuring elements b, denoted $f \oplus b$ as is defined as (Gonzalez et al, 2004):

$$(f \oplus b)(x,y) = \max\{f(x-x'),(y-y')+b(x',y') \mid (x',y') \in D_b\} \tag{1}$$

where $D_b$ is the domain of $b$, and $f(x,y)$ is assured to equal $-\infty$ outside the domain of $f$.

Gray scale dilation in this study was performed using flat structuring elements where $D_b$ is defined as:

$$b(x',y') = 0 \; for (x',y') \in D_b \tag{2}$$

The gray scale dilation equation is simplified as:

$$(f \oplus b)(x,y) = \max\{f(x-x',y-y') \mid (x',y') \in D_b\} \tag{3}$$

Flat structuring gray scale dilation is a local maximum operator where the shape at $D_b$ determined a set at pixel neighbors.

### Morphological Closing

Closing an image with a disk structuring element smoothes the contours, fuses narrow breaks and long thin gulfs, eliminates small holes and fill gaps on the contours (Haralick et al, 1987). The closing of $f$ by $b$, denoted $f \bullet b$, is dilation followed by erosion (Gonzalez et al, 2004):

$$f \bullet b = (f \oplus b) \ominus b \tag{4}$$

## *The Proposed Method*

### Mammographic Phantom

The mammographic phantom was created with embedded structures of various sizes of fibres (fibrils), microcalcification (micronodule) and masses (nodules). The embedded structures were arranged randomly on the phantom.

The phantom materials have almost the same attenuation properties as the real tissues of breast. The embedded structures were placed on the top of Rachel Antropomorphic Breast Phantom Model 169.

### Image Acquisition

The mammographic phantom images were obtained using Hologic Lorad Seleria Full Field Digital Mammography System with a focal spot size of 0.3 mm. A variety of operating conditions was used such as under different values of kVp, mAs and filters were experimented.

### Enhancement Techniques

#### i. Intensity Transformation Functions

The method was applied as a image preprocessing technique. The method was very useful to enhance image contrast for embedded structures in gray scale image. The gamma value was set less than 1 so the mapping was weighted toward higher output values. An intensity band of embedded structures could be highlighted in the images.

#### ii. Morphological Techniques

The '*strel*' was applied in flat structuring elements for mammographic images which support arbitrary shapes (Marques, 2011). The images was dilated using a flat $4 \times 4$ structuring element. Morphological closing was applied to the image after dilation.

#### iii. Image Denoising

After segmentation using morphological techniques, the image was denoised using low pass Gaussian filter. The standard deviation $\sigma$ of the addictive white Gaussian noise was set to 0.5 (Nor'Aida et al, 2011). The estimated parameter $\sigma = 0.5$ was applied to the image.

#### iv. Measuring Image Quality

Peak signal to ratio (PSNR) and Mean Squared Error (MSE) of the output image was measured to evaluate the quality of image (Moon and Stirling, 2000).

The MSE,

$$MSE = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N}\left|x(i,j)-y(i,j)\right|^2}{MN} \quad (5)$$

The PSNR,

$$PSNR = 20\log_{10}\left[\left(\frac{2^{\eta}-1}{\sqrt{MSE}}\right)\right] \text{ dB} \quad (6)$$

## RESULT AND DISCUSSION

The pre-processing technique using intensity transformation functions and segmentation using morphological techniques are effective for mammographic phantom image enhancement. These improved the image contrast and visualization for microcalcifications and masses. Microcalcifications were more visible than masses. Figure 1 and 2 below show the original image and the image after enhancement.

**Figure 1** The original image.

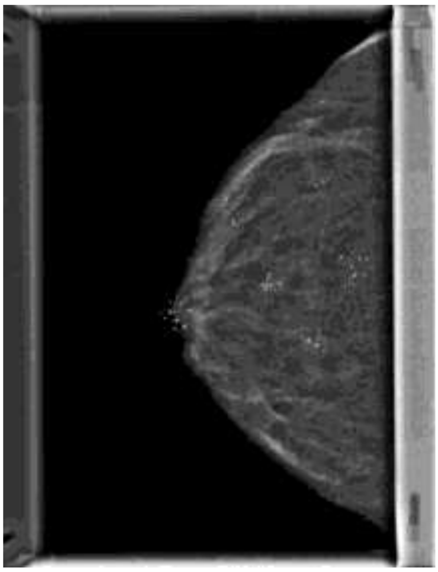

**Figure 2** The image after enhancement.

Parameter including PSNR and MSE value were computed and used as evaluation criteria to determine the performance of this method. Table 1 shows the values of MSE and PSNR obtained from two different images selected from the image database.

**Table 1** MSE and PSNR value for two different enhanced images.

| Image Dataset | MSE value | PSNR (dB) |
|---|---|---|
| Image 1 | $1.4304e \times 10^{-4}$ | 74.5680 |
| Image 2 | $2.1093e \times 10^{-4}$ | 72.8813 |

In the enhancement technique, the images were dilated using a diamond shaped structuring element of 4 × 4 to suppress noise and improve image contrast. In order to reduce elimination of any microcalcification, the size of the structuring element was chosen experimentally. The key parameter should be varied in order to render the algorithms which could able to handle different datasets with different X-ray conditions.

After the enhancement, microcalcifications appeared as bright spots with higher intensity value compared to other embedded structures including fibrils and the phantom background. Masses with low density have low contrast (Guillaume et al, 2007). Masses are often difficult to detect compared to the microcalcification because of its varying size, shape and density.

Low pass Gaussian filter was applied to the image because this filter produced higher PSNR value compared to mean filter, Wiener filter and bilateral filter (Vijaykumar et al, 2010). This filter is good in smoothening the noise after morphological segmentation and edge preservation for digital mammography image.

This method used little computing time and resources. The algorithms were simple and the implementation did not require complex computations.

## CONCLUSION

Mammogram interpretation is a difficult and challenging task for most radiologists. In this work, we demonstrated that mathematical morphology was a useful tool for microcalcifications and masses enhancement of mammographic phantom image. This proposed method give better visualization and better image contrast in early detection of microcalcifications and masses. Most electronic image processing including the digital mammographic image could generate false-positive findings.

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## REFERENCES

Alfonso, R.D. and Asoke,K.N., Detection of Masses in Mammograms via statiscally based enhancement, multilevel-thresholding segmentation and region selection, Computerized Medical Imaging and Graphics 32 , 304-315 (2008).

Diekmann, F., Heinlein, P., Drexl, J., Grebe, S., Gossler, A., Schneider, W. and Hamm, B., Visualization of Microcalcifications by Full Field Digital Mammography Using a Wavelet Algorithm, International Congress Series 1230, 526-530 (2001).

Gonzalez, R.C., Woods, R.E. and Eddins, S.L., Digital Image Processing, Prentice Hall, New Jersey, 366-374 (2004).

Guillaume, K., Tiedeu, A. and Martin, K., Automated Detection of Masses in mammograms by Local Adaptive Thresholding, Computers in Biology and Medicine 37, 37-48 (2007).

Haralick, R.M., Sternberg, S.R. and Zhuang, X., Image Analysis Using Mathematical Morphology, IEEE Transactions on Pattern Analysis and Machine Intelligence, 9, 532- 550 (1987).

Marques, O., Practical Image and Video Processing using MATLAB ®, John Wiley & Sons Inc, 299-333 (2011).

Mohideen, K., Perumal, A. and M. Sathik, Image Denoising And Enhancement Using Multiwavelet With Hard Threshold In Digital Mammographic Images, International Arab Journal of e-Technology, 2, 49-55 (2011).

Moon, J.K. and Stirling, W.C., Mathematical Methods and Algorithms for Signal Processing, Prentice Hall (2000).

Nien Yu, S., Yuei-Li, K. and Kun Kuang, Y., Detection of Microcalcifications in Digital Mammograms using Wavelet filter and Markov random field model, Computerized Medical Imaging and Graphics 30, 163-173 (2006).

Nor'Aida, Norriza and W.M Saridan, Proceedings National Science Postgraduate Conference (NSPC), Ibnu Sina Institute, UTM, 573-581 (2011).

Panda, R.N., Panigrahi, B.K and Patro, M.R, Feature Extraction for Classification of Microcalcofications and Mass Lesions in Mammograms, IJCSMS International Journal of Computer Science and Network Security, 9, 255-265 (2009).

Papadopoulos, A., Fotialis, D.I and Costaridou, L., Improvement of Microcalcificcation Cluster Detection in Mammography Utilizing Image Enhancement Techniques, Computers in Biology and Medicine 38, 1045-1055 (2008).

Vijaykumar, V.R., Vanathi, P.T. and Kanagasabapathy, P., Fast and Efficient Algorithm to Remove Gaussian Noise in Digital Images, IAENG International Journal of Computer Science, 37:1 (2010).