Contrast Enhancement of Masses in Mammograms using Multiscale Morphology

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• Breast cancer - deadly disease found mostly in women.

• The actual cause of breast cancer is yet not identified.

• If cancer is detected at the earliest stage then it can lead to high survival rate.
Masses in Mammograms

Mass: An abnormality usually appear as lump in breast. The enhancement of masses can provide an additional opinion to radiologist.
MATHMATICL MOPHOLGY

• Formulated by G. Materon and J. Seera in 1964

• Morphological methods generally include exploring of the complete image by a structuring element and at each coordinates the structuring element performs some operation with the neighbouring elements.

• It operates over sets and Sets in mathematical morphology
• An element having some shape and size
• Represented as a discrete structure on a grid where the part of grid that belongs to the structuring element has the value as 1 otherwise 0.

Fig 1.1 Disk type structuring element of radius \( R = 3 \)
Morphological operations produce an output image of the same size as the input image by applying the operations on the input image by a structuring element.

- Dilation

\[(I \ominus Se)(m, n) = \min \{I(m-I, n-j) - (Se(I, j))\}\]

- Erosion

\[(I \oplus Se)(m, n) = \min \{I(m-I, n-j) + (Se(I, j))\}\]
Erosion :-
Erosion with small (e.g. $2\times2$ - $5\times5$) square structuring elements shrinks an image by stripping away a layer of pixels from both the inner and outer boundaries of regions. The holes and gaps between different regions become larger, and small details are eliminated:
Dilation :-
Dilation has the opposite effect to erosion - it adds a layer of pixels to both the inner and outer boundaries of regions. The holes enclosed by a single region and gaps between different regions become smaller, and small intrusions into boundaries of a region are filled in:
Opening and Closing operations :-

• Opening is so called because it can open up a gap between objects connected by a thin bridge of pixels. Any regions that have survived the erosion are restored to their original size by the dilation

• Closing is so called because it can fill holes in the regions while keeping the initial region sizes.

\[ I \circ Se = (I \otimes Se) \oplus Se, \]
\[ I \bullet Se = (I \oplus Se) \otimes Se. \]
Single scale morphological filtering performs image enhancement using the morphological top hat transform corresponding to the fixed size of the used structuring element.

There is no scaling of the structuring element.
MULTI SCALE MORPHOLOGY

• A scheme of morphological operation with increasing size of the structuring element is termed as multi scale morphology.

• Multi scale opening and closing are defined as

\[ (f \circ g) = \text{Dilation} \left( \text{Erosion} \left( f, ng \right), ng \right) \]

\[ (f \bullet g) = \text{Erosion} \left( \text{Dilation} \left( f, ng \right), ng \right) \]

Where \( g \) is a structuring element of a defined shape and \( n \) is an integer representing the scale factor of the structuring element.
There are two versions of mathematical morphology,

a) white top-hat

b) black top-hat.

The white top-hat transformation is defined as the resultant between the original image and its opening.

The black top-hat transformation is the resultant between the closing of an image and the original image.

\[
f_{WTH} = ((f - (f \circ g)) (x, y)
\]

\[
f_{BTH} = ((f \cdot g) - f) (x, y)
\]
• Step 1:- Images obtained from the mini MIAS database are cropped manually. The cropped images are of the size 200 x 200 with the region covering the masses.

• Step 2:- Let there be a sequence of multiscale structuring elements having the same shape but increasing sizes: $g_0, g_1, g_2, \ldots, g_m$. 
Input image

Crop the image to obtain ROI

Select the structuring element

Extract white and black image regions at each scale

Find the sum of all white regions at each scale

Find the sum of all black regions at each scale

\[ \sum \]

Obtained image

Take difference of obtained image and its complement

Enhanced image (D)

Stop
• Step 3:- The white and black image regions are extracted at each scale

\[ TH_i = f - (f \circ g_i) \] and \[ BH_i = (f \bullet g_i) - f \]

• Step 4:- Average of the \((i-1)_{th}\) scale and \(i_{th}\) scale is calculated for white as well as black image regions

\[ f^{th} = 0.5 \times (TH_i + TH_{i-1}) \] and \[ f^{bh} = 0.5 \times (BH_i + BH_{i-1}) \]
• Step 5:- morphological filtering of the image is obtained by adding the difference of white image regions and the black image regions to the original image

\[ f^{(k)} = f + f^{\text{th}} - f^{\text{bh}} \]

• Step 6:- procedure described from step 2 to 4 is iteratively repeated by using the output image from the kth iteration as the input image for the next, \((k+1)\)

\[ f^{(k+1)} = f^{(k)}, \quad k=1,2,3\ldots \]
• Step 7: Additional background suppression without affecting already extracted bright details is obtained by taking the difference between the obtained image and its compliment described as follows,

\[ f^k_C = 1 - f^k \]

\[ D = f^k - f^k C \]
The proposed algorithm is applied to a set of nine mammographic images to see the qualitative as well as quantitative performance of the proposed algorithm.

Results of the images when subjected to different type of enhancement techniques like histogram equalization, single scale morphological filtering, Stojic’s Method [6] and the proposed method is shown along with the original cropped ROI of the image.

Respective MSE and SNR values of each enhanced image is also calculated.
ENHANCEMENT OF MAMMOGRAMS

Original Cropped ROI

HE

Single Scale Morphology

Stojic's Method

Proposed Method

MSE

6.66424

4.65347

5.79525

3.81646

SNR

31.6558

34.7753

32.8694

36.4976

REFRESH
ENHANCEMENT OF MAMMOGRAMS

Original Cropped ROI
HE
Single Scale Morphology
Stojic's Method
Proposed Method

MSE
41.8481
5.12088
8.06118
4.65314

SNR
15.6973
33.9439
30.0028
34.7759

REFRESH
ENHANCEMENT OF MAMMOGRAMS

- Original Cropped ROI
- HE
- Single Scale Morphology
- Stoic's Method
- Proposed Method

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<th>SNR</th>
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REFRESH
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• In this paper, a very simple and efficient image enhancement algorithm has been implemented for contrast enhancement of medical images using morphological image processing.
• Experimental results showed that the proposed method performs better than the other three techniques in terms of contrast enhancement.
• This algorithm can be extended through the use of non flat structuring elements.

• Other quality metrics can also be used to judge the performance of the proposed algorithm.
REFERENCES

THANK
YOU