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Contrast Enhancement of Mammograms using Morphology

Jasleen Kaur Chahal
M. tech Student, EE Dept.
BBSBEC
Fatehgarh Sahib, India

Navneet Kaur Panag
A.P., EE Dept.
BBSBEC
Fatehgarh Sahib, India

Abstract--This paper represents a contrast enhancement of the mammographic images using multi-scale structuring elements in the mathematical morphology operation. The white image regions are extracted out while the darker background image elements are suppressed. With the help of the proposed algorithm the features of the image become clearer. Also the comparison of the proposed algorithm is done with the state-of-art techniques. On comparison it has been obtained that the results of the proposed algorithm are much more efficient as compared to other techniques.

Keywords—Contrast Enhancement, Mathematical Morphology, Multi-Scale Morphology, Mammographic images.

I. INTRODUCTION

The significant health problem for women in the whole world is Breast Cancer. The main field in the medicine area of breast cancer is the early detection of the cancerous masses. To detect the cancerous masses manually is a very difficult task; highly experienced radiologist is required for the detection, which can also be sometimes prone to error because the mammographic images are of low contrast. So a computer aided design has been developed for the efficient detection of the masses. A number of algorithms are available in the literature review of the enhancement techniques [1, 2, 3]. Conventional mammographic techniques do not produce desired results over the mammographic images. To obtain the efficient results in the contrast enhancement of the mammographic images the structuring element with the varying scale are used.

II. MASSES

During the mammography of the breast the bright and the hyper dense objects found are termed as masses. Masses are categorized into different types: cysts (non-cancerous, fluid filled sacs), benign (non-cancerous solid tumors), and malignant (cancerous tumors). The two solid tumors are compared together in the table below.

Table 1: Comparison between the benign and malignant tissues.

Benign	Malignant
These are having smooth and well circumscribed boundary.	The boundary of these masses is speculated, rough and blurry.
These are not merely life threatening.	These are life threatening tissues.
Do not interact with other tissues.	Highly affect the nearby tissues and organs.
Once removed, generally don't come back	Chances of coming back are high.
Other body parts are not affected.	Complete body is affected as it enters to the blood stream.

III. MAMMMOGRAPHY

The process of taking X-ray of breast using lower energy as compared to the normal X-ray is known as mammography. Now days, digital detectors are used for the mammography. Different types of mammograms are used at the different stages such as: for the person with no symptoms of breast cancer screening is done, for the persons who have symptoms like hardening of surface, increased size breast diagnostic mammograms are performed. As the mammography is of low contrast so enhancement is to be done, for that there are several techniques like histogram equalization, morphological analysis, and various matching techniques.

IV. STRUCTURING ELEMENT

The characteristics of the input image are examined with the help of structuring element. A matrix of 0's and 1's of any shape and size, with the shape and size dependent upon the object in the input image is referred to as structuring element. The two commonly used techniques for the image enhancement are dilation and erosion which are highly dependent upon the structuring element. The shape and size of the structuring element are defined as follows:

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a) Size: The size of the structuring element is completely dependent upon the size of the object that is to be extracted from the input image. The size can vary from 3×3 pixels or 5×5 pixels, etc.
b) Shape: Structuring elements are of different shapes such as: bell, diamond, disk, line, ring, convex, etc.

V. LITERATURE REVIEW

Megha M. et al [1] proposed an algorithm that is using top-hat transformation on the histogram equalization and contrast limited adaptive histogram equalization (CLAHE) for the enhancement of the mammographic images. In the algorithm firstly the image has been cropped and resized it to 256×256 pixels to standardize the image. Then the red, green and blue regions are extracted from the image. Next, the top-hat transformation is applied onto the structuring element. Then obtained images are added together to form a new enhanced image. Over the enhanced image firstly the histogram equalization is applied and after which adaptive histogram is applied. The red, green and blue components are joined together to obtain the composite image. The obtained results were good but the drawback of the algorithm came out was that the image was globally enhanced.

Bai et al [2] proposed an algorithm which is unified based upon multi-scale top-hat transformation. The unified algorithm was designed by integrating the already existing algorithms. The major function of the unified algorithm is supported with the help of proper examples. The proposed algorithm is applied onto the noise suppression, multi-focus image fusion, and local contrast enhancement. The algorithm is carried out into three steps: calculating multi-scale top-hat transform, extracting the useful features, and reconstructing the final image.

Singh et al [3] proposed a method for the contrast enhancement of the mammographic images. The method for the proper enhancement of the image is divided into different sections: image reduction, create a breast map and normalize the image, defining the ROI, and the image enhancement.

Kumar et al [4] introduced a new algorithm for the enhancement of mammographic images. The two root stems of the algorithm were mathematical morphology and wavelet transform. The steps for the enhancement carried out were: the extraction of the mammographic image, applying Gaussian low pass filters, mathematical morphology is applied onto the low frequency components and edge enhancement is applied on high frequency components, on combining both the enhancements contrast of the image is enhanced and the wavelet de-noising is applied to get the properly enhanced image.

Wu et al. [5] proposed a new algorithm for the feature and contrast enhancement of the mammographic images. The proposed algorithm was carried out as follows: the input image is extracted, then the Gaussian low pass and high pass filters were used to separate out the lower and the higher frequencies, then the morphological operation was applied onto the lower frequency components and CLAHE, combining these Laplacian Gaussian pyramid is constructed, the final step is applying the global contrast enhancement scheme to get the properly enhanced image.

Kamra and Jain [6] explained that there are various instrumental techniques for the enhancement which are helpful for the radiologists to detect and diagnose subtle signs in mammograms with more accuracy and reliability. In their paper, they have suggested a morphological based enhancement for the enhancement of distorted architecture consisting of subtle signs. The results in the paper show that the proposed method is showing the better results in subjective as well as objective way.

VI. MULTI-SCALE MORPHOLOGY

The image features that are to be enhanced are extracted. The extracted features in the multi-scale morphology are can be of different shapes as well as sizes. In multi-scale morphology the structuring element used is of different shapes and sizes, as the usage of structuring element with same size does not produce the efficient amount of information that is required. Multi-scale morphology can be applied onto the input image in the following way:

Firstly; the input image is to be taken. Then, it is assumed that a sequence of structuring elements with same shape and increasing size are applied onto the image.

Next the white and the black image regions are extracted at each scale of structuring element with the help of following equations (1) and (2).

$$TH_i = f - (f \circ Se_i) \quad (1)$$

$$BH_i = (f \bullet Se_i) - f \quad (2)$$

To get the morphologically enhanced features the difference of the top hat and bottom hat is added to the original image as stated in the following equation (3).

$$f_k = f + f_{th} - f_{bh} \quad (3)$$

This process is iteratively repeated for all scales of structuring element to get the properly enhanced image.

VII. RESULTS

The following figures show the enhancement of mammographic images with the multi-scale morphology and also the comparison of the proposed algorithm with the other algorithms, such as Histogram Equalization and Single-Scale Morphology.

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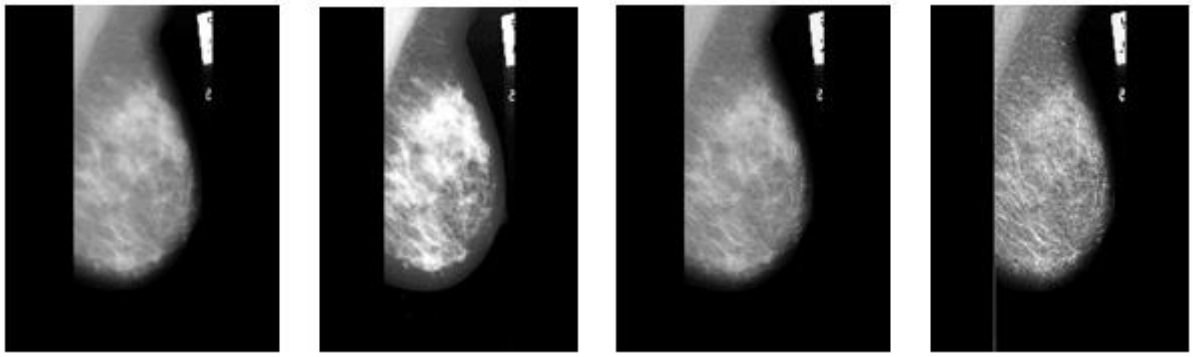
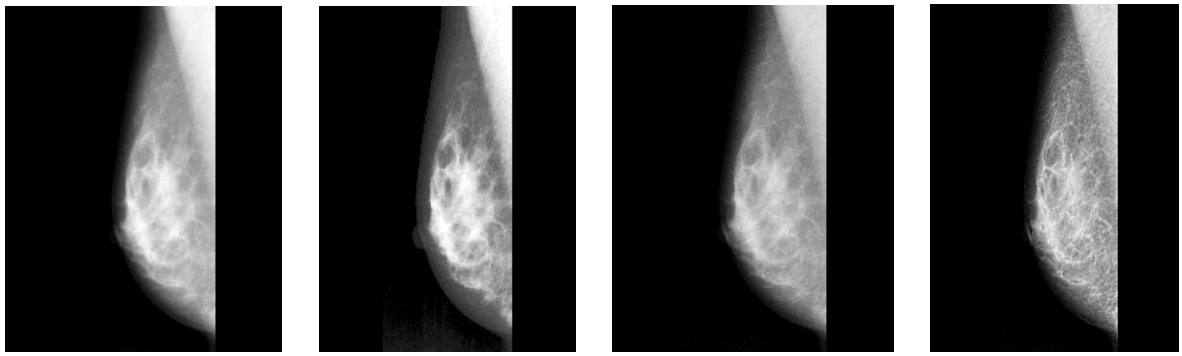


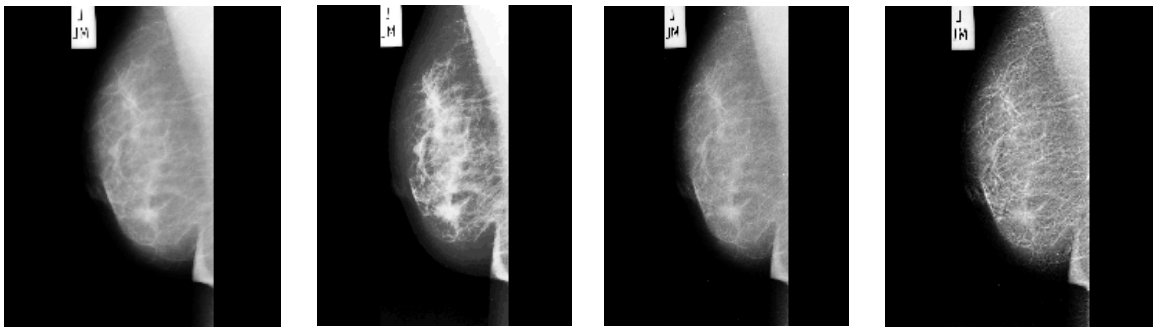
Original Image Histogram Equalization Single Scale Morphology Multi Scale Morphology

Figure 1 Various Enhancement Techniques



Original Image Histogram Equalization Single Scale Morphology Multi Scale Morphology

Figure 2 Various Enhancement Techniques



Original Image Histogram Equalization Single Scale Morphology Multi Scale Morphology

Figure 3 Various Image Enhancement techniques

VIII. CONCLUSION

The contrast enhancement of the mammographic images has become important issue for the proper recognition of the cancerous masses. From the above discussion and the results obtained it has been cleared that the enhancement of masses with multi-scale morphology are clearer as compared to the enhancement of masses with the other techniques.

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