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Deep learning enhancement on mammogram images for breast cancer detection

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ABSTRACT

The mortality rate due to breast cancer can be controlled if the process of classification of breast lesions is done correctly which could be either malignant or benign. With the help of this process, we can reduce this rate up to a great extent. It has been observed that this process seems to be complicated. The reason behind this is the presence of errors in the detection of noise pixels as false positives. Mammogram images play a vital role in the process of breast cancer examination. These give the indication of cancer which needs to be targeted. A proper enhancement in them is required which will further help to reduce the complications. A mammogram is a poor quality image that requires an improvement in order to be better defined. The viability of the pre-processing techniques for amplifying a mammogram image is eliminated by performance metrics. Good filtering process with high PSNR and low MSE value. The suggested techniques have been implemented in the Mammographic Image Analysis Society. It contains a huge number of images i.e. 322. The segmentation technique used is thresholding, which is applied to the enhanced image. It helps in achieving the required results.

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1. Introduction

Women die due to many causes, out of these breast cancer is second in the list just after lung cancer [1]. India averages lakh cases per year of breast cancer in the 55–59-year group. As per the viewpoint of the International Agency for Research on Cancer, the number of people infected with the disease could rise to 27 million by 2030. A study by the National Cancer Institute showed that one out of eight women in the US was diagnosed with breast cancer during their lifetime [2]. If it is diagnosed and detected early, then the probability of getting success and full recovery of the patient increase rapidly. Mammography tests are considered the best option as it is one of the most reliable imaging programs for the diagnosis [3]. Sometimes it is difficult for a radiologist to diagnose the symptoms of cancer such as masses, citing as a result of the low variation [4] of the mammograms image shown in Fig. 1. Computer diagnostic programs play an important role in accurate detection by providing mammogram images that are first processed. This is processed for better contrast and the restored image brightness is also not affected. The information stored in the image should be handled with such magnification methods because the loss of data can lead to false interpretation of the results which can further lead to significant losses. Mammograms should indicate the difference between the delicate and normal dense tissues that are considered to be below the value of threshold of human impression graphically [5]. Therefore, the basic improvements required in mammography are to increase in contrast, to improve the features of the image to imagine the effects of the image in the open eye.

The roadmap of this paper is well ordered: various techniques and datasets that are used included in section 2, section 3. represents the steps that are applied on mammogram images for preprocessing, enhancement of the images by using different methods is done in the first step, and using the enhanced image, segmentation of the image is done by removing all the artifacts that are not required in classification process is done in the second step. In the second step, segmentation is done by using thresholding. The results obtained and discussion part is elucidated in section 4 and its conclusion is explained in section 5.

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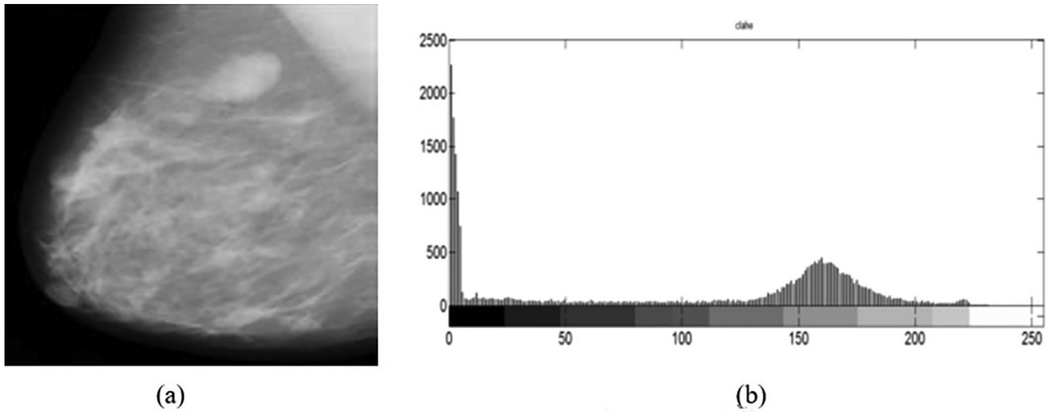


Fig. 1. a) Original mammographic image b) Histogram of Original image.

2. Various techniques and datasets used

Enhancement of the mammogram images by using various enhancement techniques such as CLAHE, DNN based enhancement. In the second stage, segmentation is done on the enhanced image by using thresholding.

2.1. Image database

Mammographic Image Analysis Society (MIAS) [6] is used for the implementation of the methodology used in the manuscript. In total, the database consists of 322 images that are further divided into three categories. All these images have been labeled by experts. Out of 322 images 208 images are labeled as normal, 63 images are labeled as benign or micro and the rest images are labeled as malignant or abnormal images. The original pixel size of the image is 1024 $\times$ 1024.

2.2. Process of binarization of image

Its a procedure in which an image that has its pixel value from 0 to 255 also known as grayscale image converted into an image that has its pixel value either 0 or 1 known as binary image [7]. The converted image or binary image (I) have only two-pixel values i.e. 0 and 1 as shown in equation (1). This process is used in segregating the objects present in the foreground from the background [8].

$$I: (X, Y) \rightarrow 0,1 \quad (1)$$

After the process of binarization the image has pixel values either 0 or 1. The process of converting the pixels into black based on a certain pixel value is known as thresholding. Through this process the objects and its background both are segregated based on the threshold value [9]. Threshold-based algorithms are divided into blocking categories at one and different levels. Otsu's method is the most preferred method of universal control [10]. It automatically performs blocking an image based on the histogram status of the gray image completion in a binary image. An algorithm based on image fragmentation, Otsu's process selects a fine limit by increasing the contrast between classes [11,12]. The various steps used in Otsu process is shown in Fig. 2.

2.3. Contrast enhancement

This approach is very helpful in the operation of the medical image because contrast is a vital component in evaluation of quality of image that is subjective in nature. It is produced by calculating the dissimilarity in luminance returned from two nearby surfaces. In other words, contrast is the variance in visible effects that makes an item identifiable from another item and its background. In visual perception, contrast is calculated by the change in color of the item and its brightness with other items. The methods used in this paper are shown diagrammatically in Fig. 3.

In CLAHE, image variability was enhanced by using CLAHE method [13]. It works in tiny locations in images called tiles unlike the whole picture. The separation of each tile is improved, with the intention that the local histogram of the results is almost equal to the possible spread. Deep learning based enhancement works on the whole image and works on pixel by pixel to improve the contrast of the image. Algorithm learns from images to how to enhance the image by using already a pretrained network "dncnn".

2.4. Performance metrics

Image range can be humble. It may differ from one person to another, so for this reason it is necessary to fix some variables to check the quality of image [14 –16]. The following could be the matrix accustomed to quantify the productiveness of enhancement strategies:

2.4.1. Mean square error (MSE)

MSE is the average of square of change in the value that is estimated and the value that is actual. Lesser when the MSE value, lowers the error, which is why the image quality has a better effect. MSE is offered by:

$$MSE = \frac{1}{m \times n} \sum_{i=0}^{m-1} \sum_{j=0}^{n-1} [I(i,j) - K(i,j)]$$

where I(i,j) is the input image, m $\times$ n is the size of image and K(i,j) is the output image.

2.4.2. Peak signal-to-noise ratio (PSNR)

It is a term used for calculating the ratio of maximum power of signal which could be possible and the power of noise which is corrupted in nature. It is represented on the system of measurement of logarithmic decibel. The greater the number of PSNR, the lower the error rate, which is why increases the quality of the product or the lead image. PSNR is offered by:

$$PSNR = 10.\log_{10}\left\{\frac{I_{MAX}^2}{MSE}\right\}$$

where IMAX is the highest pixel value in the image.

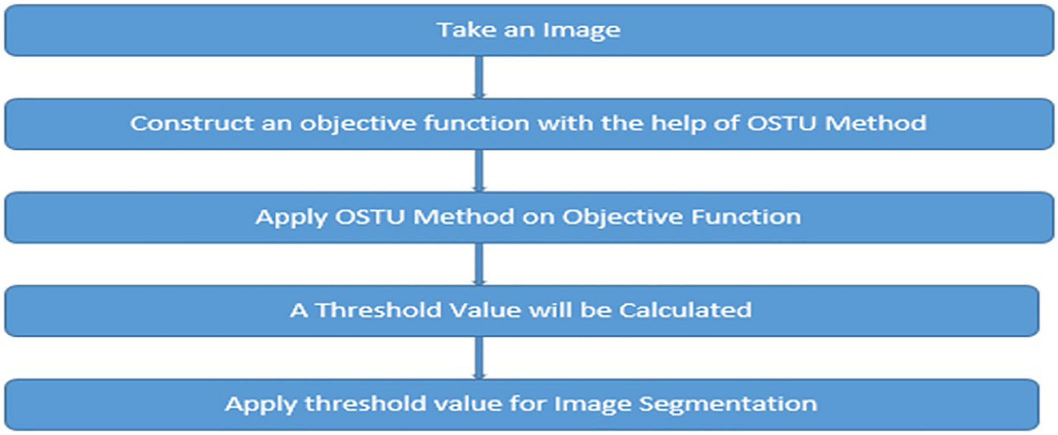


Fig. 2. Steps involved in OSTU Segmentation.

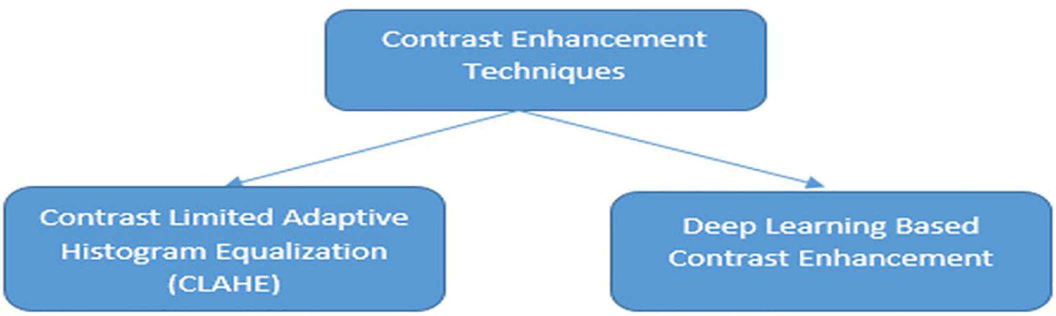


Fig. 3. Various methods for enhancement of images.

3. Basic flowchart for preprocessing

The steps required for the enhancement of the mammogram image and after that segmentation of the enhanced image is shown in Fig. 4.

The output images of enhancement process are shown in table 1 and table 2 and for segmentation process images are shown in tables 3.

4. Experimental results

Two techniques are applied to all images captured on the MIAS Dataset and the effectiveness of these enhancement methods is measured with the help of the metrics discussed earlier. PSNR and MSE values are calculated for all the images present in dataset and out of those only for 8 images values will be shown in table 4 and table 5 respectively. To check the better quality of the image, the value of PSNR must be high and the value of MSE must be

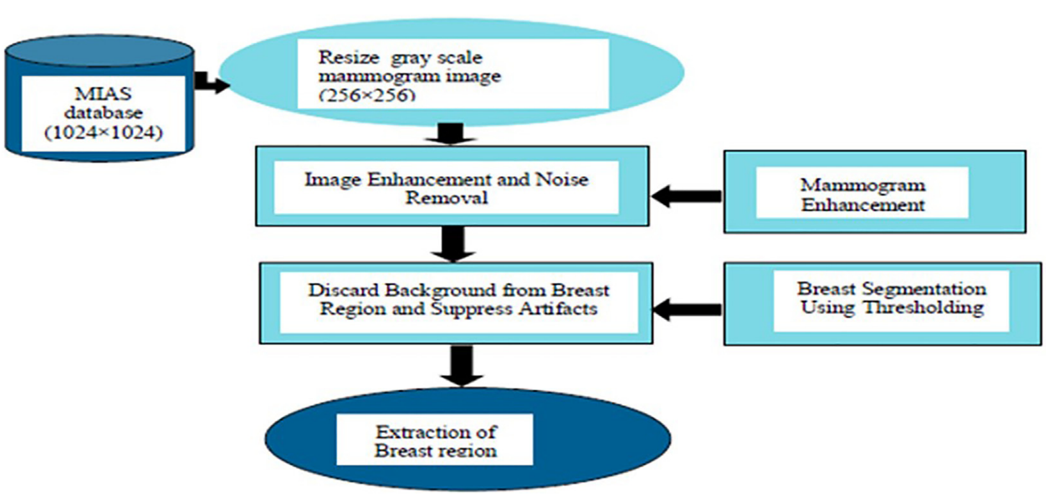


Fig. 4. Flow Chart for pre-processing.

Table 1
Output of various images after enhancing taken from dataset.

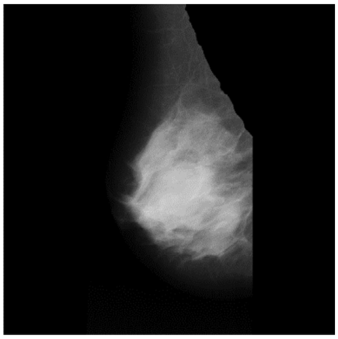
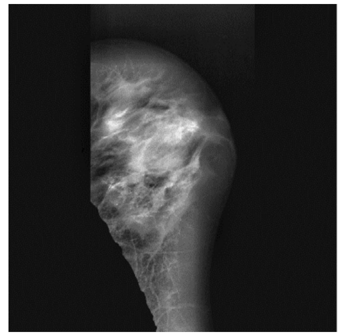
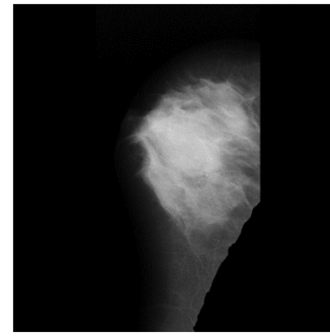
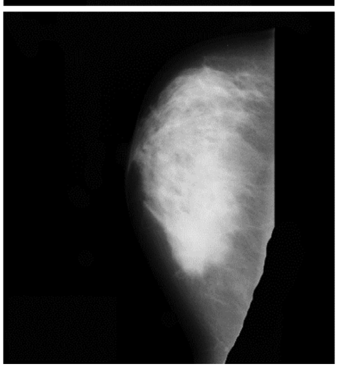
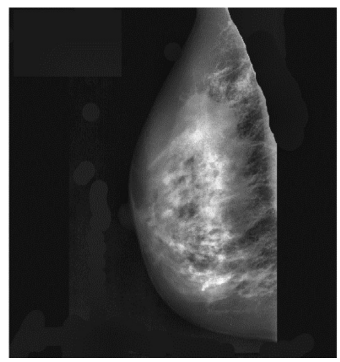
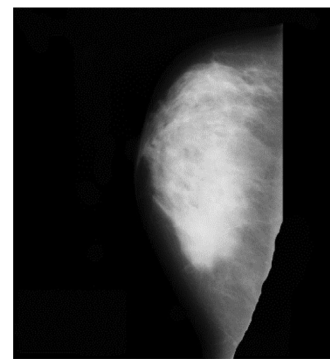
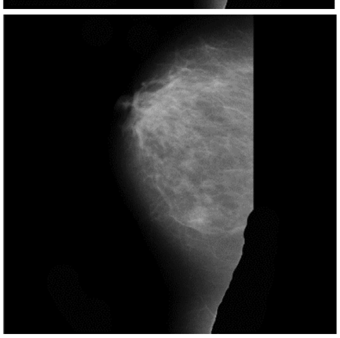
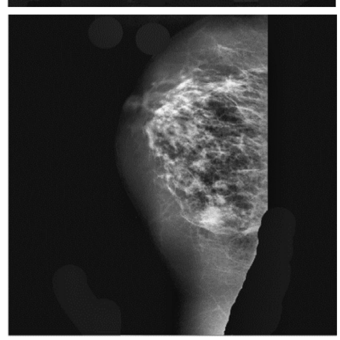
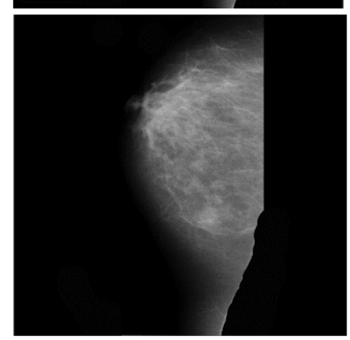
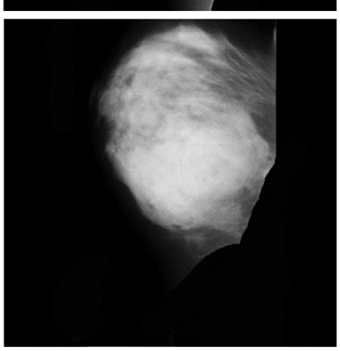
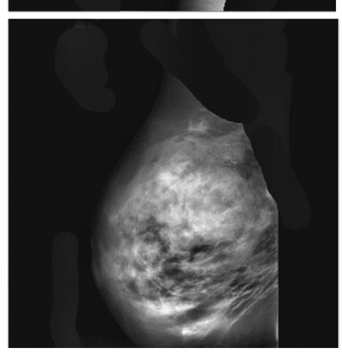
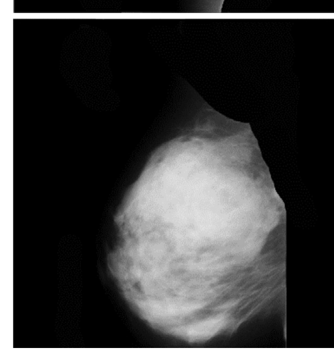
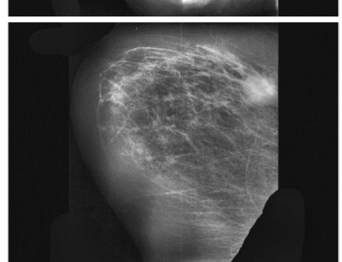
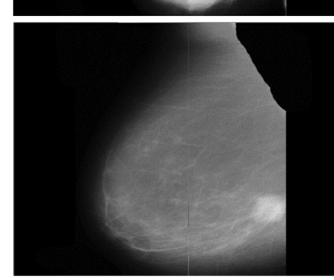
Image name	Original image	CLAHE Enhanced image	Deep learning based enhanced image
Mdb001.pgm			
Mdb003.pgm			
Mdb087.pgm			
Mdb163.pgm			
Mdb271.pgm			

Table 2
Histogram of various output images taken from dataset.

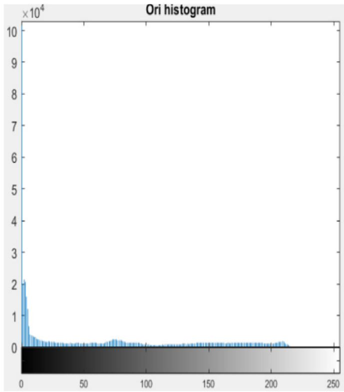
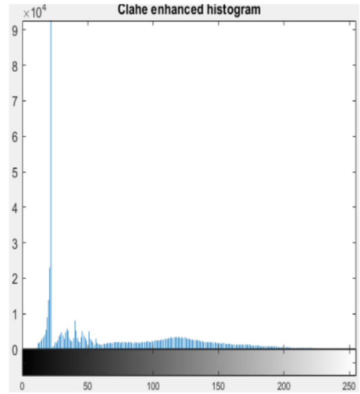
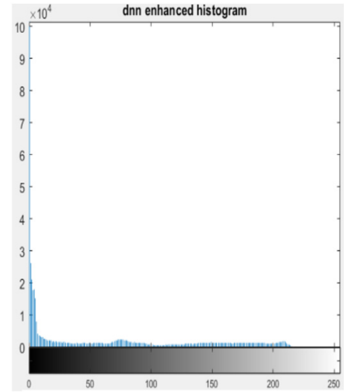
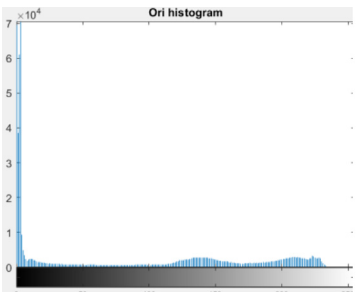
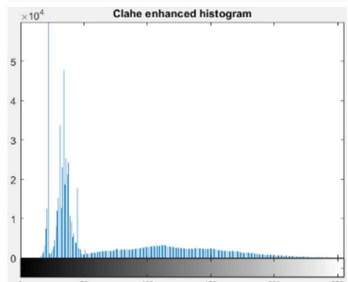
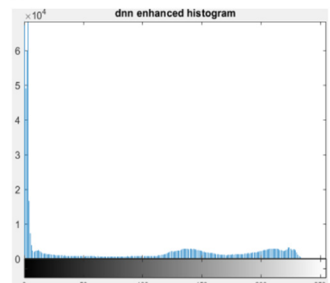
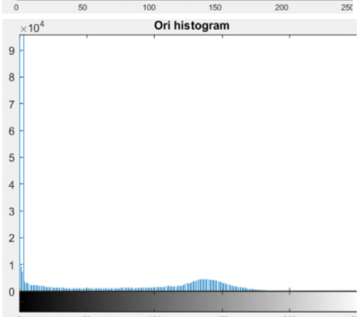
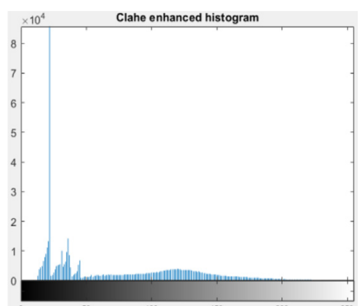
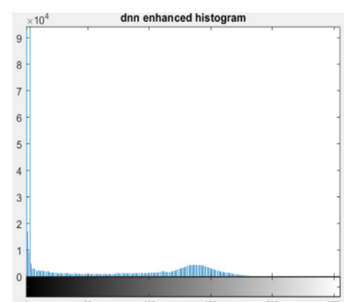
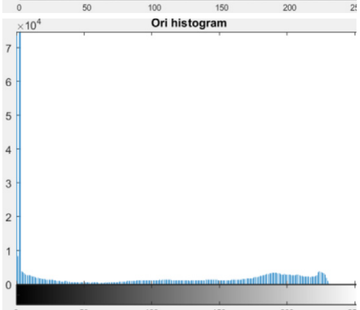
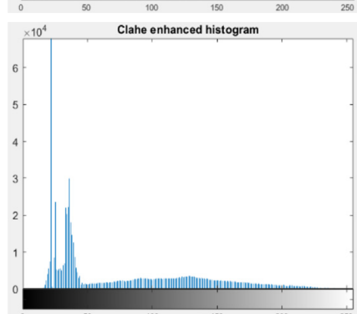
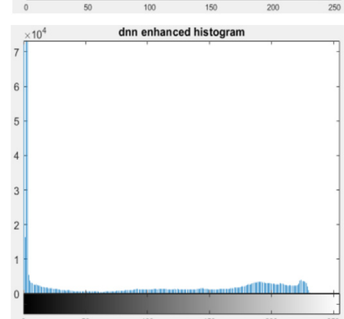
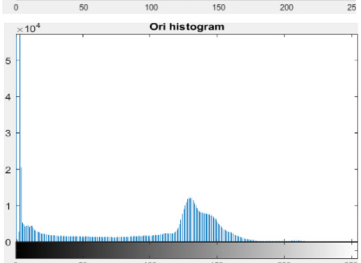
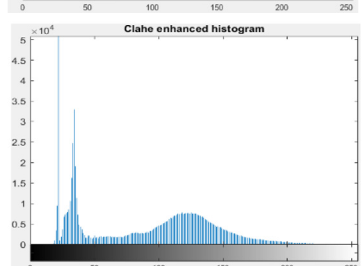
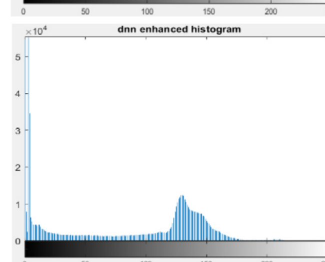
Image Name	Original image Histogram	CLAHE Enhanced histogram image	Deep learning based enhanced histogram image
Mdb001.pgm			
Mdb003.pgm			
Mdb087.pgm			
Mdb163.pgm			
Mdb271.pgm			

Table 3
Output of various images after segmentation.

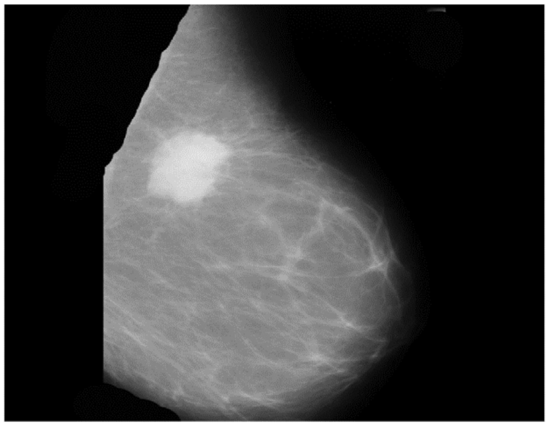
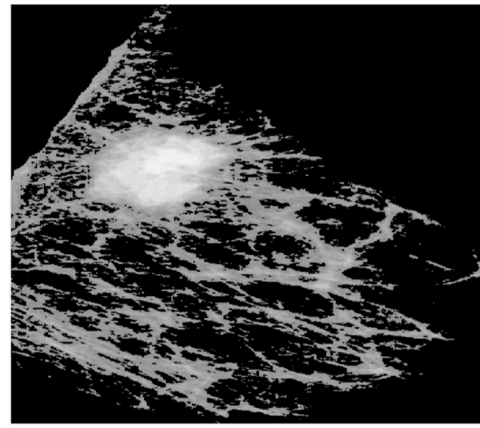
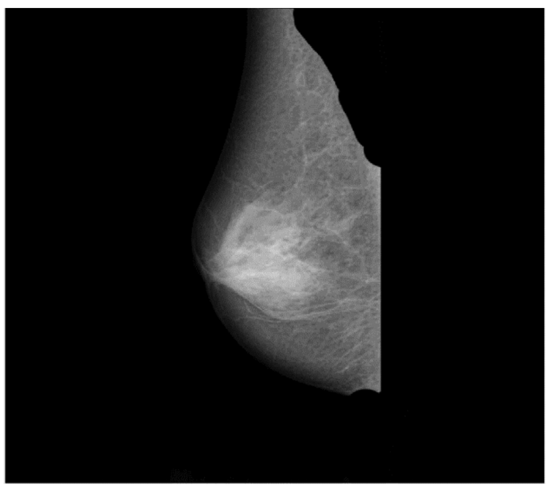
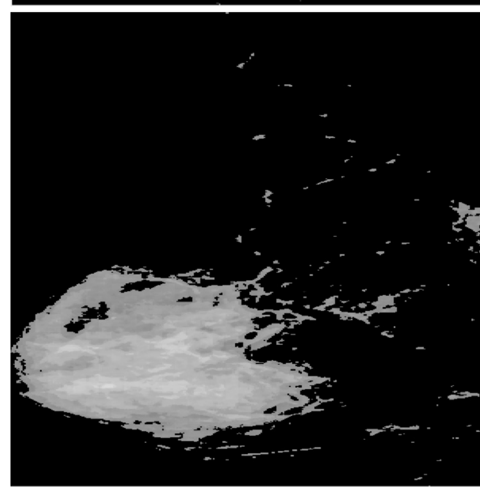
Image Name	Enhanced Image	Segmented Image
Mdb184.png		
Mdb165.png		

Table 4
PSNR output.

Image name	CLAHE	Dnn based approach
Mdb001.pgm	18.474	59.166
Mdb003.pgm	17.97	58.263
Mdb087.pgm	18.93	57.91
Mdb163.pgm	17.88	59.61
Mdb216.pgm	16.97	58.244
Mdb271.pgm	19.008	56.4417
Mdb270.pgm	20.0104	57.3892
Mdb265.pgm	19.4185	59.4903

Table 5
MSE Values.

Image name	CLAHE	Dnn based approach
Mdb001.pgm	923.93	0.0788
Mdb003.pgm	1037.49	0.097
Mdb087.pgm	831.52	0.1051
Mdb163.pgm	1058.87	0.071
Mdb216.pgm	1304.96	0.0974
Mdb271.pgm	818.4616	0.1475
Mdb270.pgm	648.694	0.1186
Mdb265.pgm	743.4164	0.0731

low. As shown from Fig. 5 and Fig. 6 respectively DNN based enhancement has high PSNR and Low MSE for all the images. Its clear Dnn based enhancement gives better image quality as compared to other technique in terms of matrices used.

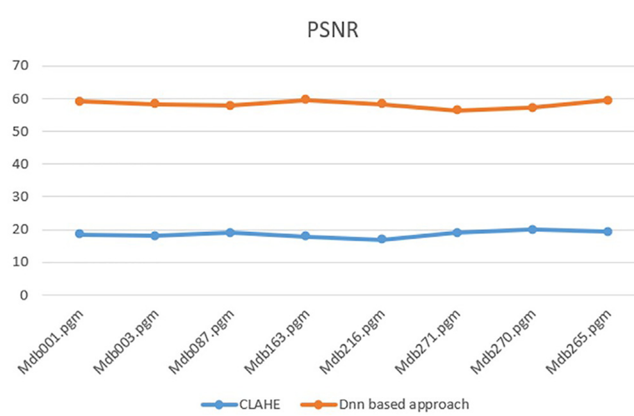


Fig. 5. Diagrammatically analysis of PSNR values.

5. Conclusion

Comparative analysis of techniques applied for enhancement of image such as CLAHE and DNN based proposed in this paper. Techniques applied on all the images captured in the MIAS database. From the analysis, it is concluded that MSE values of DNN-based technology is small and similarly the PSNR values of the DNN-based approach are very high. It means that a DNN-based process is the best way to MIAS images from the above-mentioned strategies and offers better performance than other processes. DNN-based enhanced images will be taken for image segmentation.

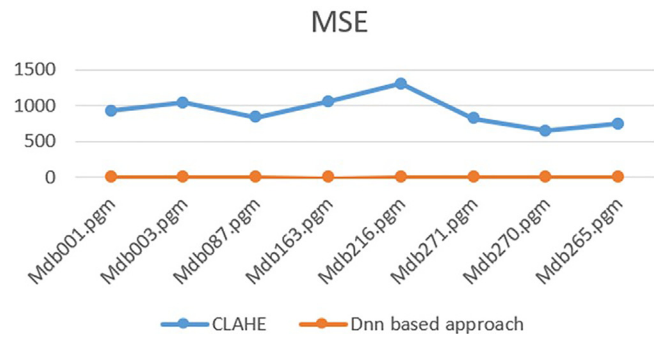


Fig. 6. Diagrammatically analysis of MSE values.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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