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DICOM Image Enhancement of Mammogram Breast Cancer

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Abstract--Mammogram breast cancer images have the ability to help oncologist in detecting disease caused by cells normal growth. Developing algorithms and software to analyze these images may also help oncologist in their daily work. During this study we dell with DICOM images which has become a standard for medical imaging. Its purpose is to standardize digital medical imaging and data for easy access and sharing. There are many commercial viewers which support DICOM image format and can read metadata, but image displaying is not always optimal. The DICOM images suffer from a poor contrast quality and noises. While the image is enhanced, the speckle noise present in the images is also enhanced so we need to remove the noise from the image before improving the contrast of image [1]. In this paper we employ a new method for correct displaying, denoising and enhancement the contrast of DICOM images concentrating on breast images.
Keywords--DICOM, image enhancement, breast cancer, histogram equalization, Noise

I. INTRODUCTION

Cancer is a collection of diseases that cause cells in the body to grow out of control and change. Most types of cancer cells eventually form a masses or lump called a tumor, and are named after the part of the body where the tumor originates. Breast cancer begins in breast tissue, which is made up of glands for milk production, called lobules, and the ducts that connect lobules to the nipple. The remainder of the breast is made up of fatty, lymphatic, and connective tissue [2]. Early and efficient detection is the most effective to reduce mortality, and currently a screening programmer based on mammography is considered one the popular and best method for detection of breast cancer. Mammography is a low dose X-ray procedure that allows visualization of the internal structure of the breast. Mammography is highly accurate, but like most medical tests, it is not perfect. On average, mammography will detect about 80–90% of the breast cancers in women without symptoms [3].

As digital technologies are incorporated in every aspect of our lives, they are also the key part of medical diagnosis. DICOM (Digital Imaging and Communications in Medicine) standard was developed to make sharing of medical information safe and above all standardized. Having a standard in digital medical imaging improves flexibility and speed in detection and getting a fast diagnose .DICOM version 3.0 is used today and has become a standard in medical imaging and file exchange [4]. DICOM supports grayscale and color images of different formats. Besides image data, DICOM includes image-related data that are stored in the header of an image file. Some of the information included in the header is image resolution, image type, number of stored bits, patient's name, etc. Software for viewing mammography images in most cases is provided by the manufacturer of medical imaging hardware [5].

II. MATERIALS AND METHODS

The database of mammograms used in this work is acquired from Mansoura advanced radiology center .the entire method presented in this paper was implemented using MATLAB 7.0, and makes extensive use of the Image Processing Toolbox. Our methodology is shown in Fig. 1 which consists of three main stages. Firstly, we apply the pre-processing stage. Secondly, we apply noise removal stage and finally, the enhancement stage.

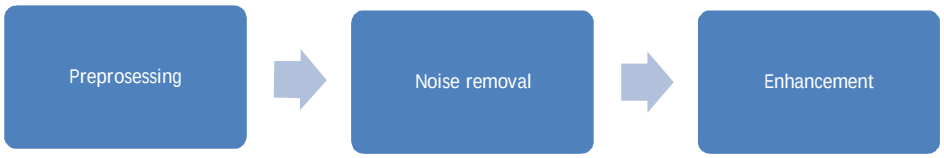

Fig. 1: Proposed Algorithm

A. *Preprocessing*

The Preprocessing stage is the first stage in proposed algorithm which uses to correct displaying of dicom image and it involves

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six steps as shown in Fig. 2.

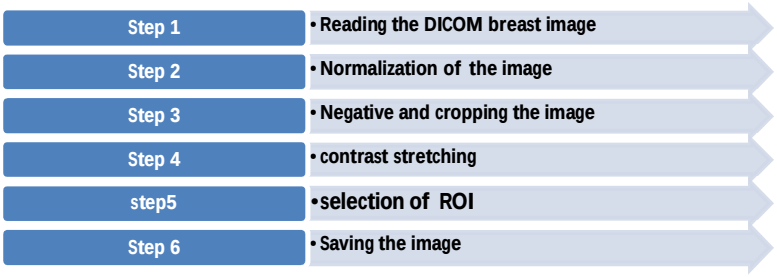
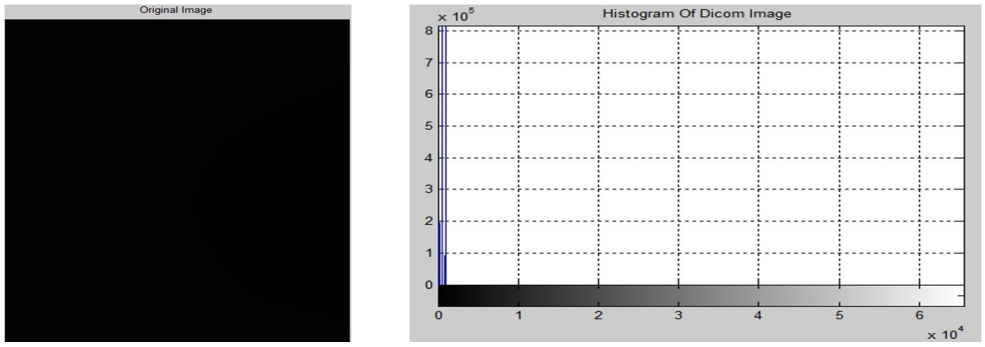


Fig. 2: the structure of Preprocessing Stage

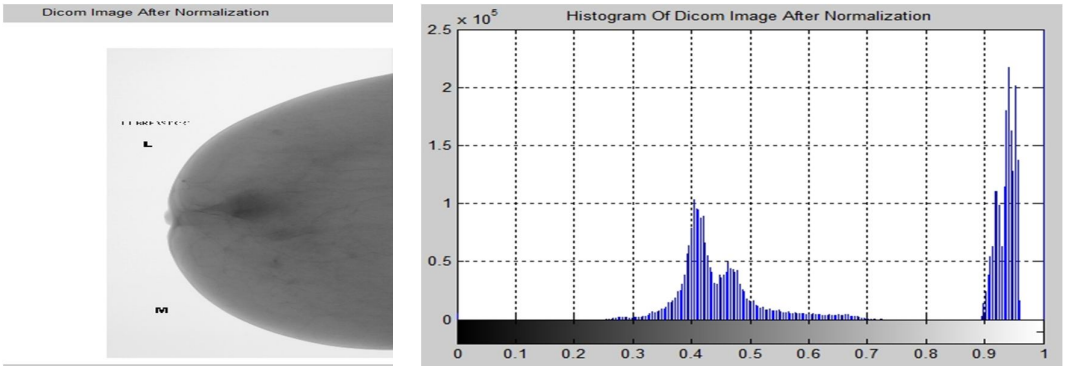
Step 1 of the preprocessing stage is reading the images from DICOM files and we used dicomread function in Matlab image processing toolbox. As shown in Fig. 3 the DICOM image has a poor contrast and its histogram is very narrow.it reflects the poor vision of the machine and human also.



(a) (b)

Fig. 3: (a) Original Image and (b) its Histogram

Step 2 aims to convert a data matrix to a grayscale image whose values represent intensities within some range. MATLAB stores a grayscale image as an individual matrix; with each element of the matrix corresponding to one image pixel. We used mat2gray function in Matlab image processing toolbox which converts the matrix of input image to the intensity image (output image). The output matrix contains values in the range 0.0 (black) to 1.0 (full intensity or white) [6]. As shown in Fig. 4 the image become very clear compared with the original image in the previous image and the histogram become wide compared with the histogram shown in fig 3 (b).



(a) (b)

Fig. 4: (a) dicom image after normalization, (b) its histogram

Step 3 makes a negative of image using the imcomplement function as shown in Fig. 5(a). After that the unnecessary area of image is cropped by imcrop function of Matlab software. The result of this step is shown in Fig. 5(b). The histogram of crop image is shown in Fig. 5(c).

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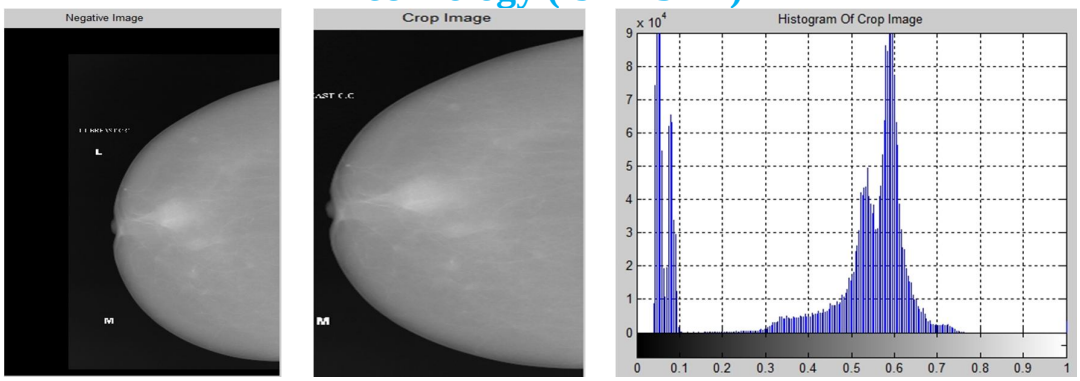
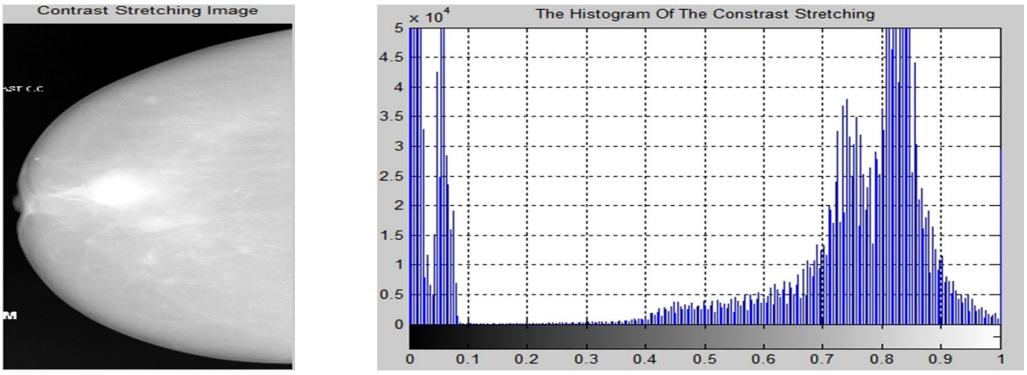


(a) (b) (c)

Fig. 5: (a) negative image ,(b) crop image and (c) histogram of crop image

Step 4 aims to contrast stretching by using imadjust to stretch the contrast of the image by mapping the values of the input intensity image to new values such that, by default 1% of the data is saturated at low and high intensities of the input data[6]. We used Matlab functions to do this. As shown in fig. 6(a) the image is more clearer than the previous image in fig .5 (b) and its histogram is redistribution from 0 to 1as shown in fig .6(b).



(a) (b)

Fig:6 (a) image after contrast stretching and (b) its histogram

Step 5 aims to selection the Region of interest (ROI) which is a portion of an image that contains the important data needed in our studying and.to do this task we used the Matlab function as shown in the following command.

f = imadjust (I, [gray1 gray2], []) command

Where,

f = output image

I = input image

gray1 and gray2 are selected by using imcontrast which creates an adjust contrast tool in a separate figure that is associated with the grayscale image in the current figure, called the target image[6]. As shown in fig: 6 (b) the image consists of three region and we need to select the region which it contains the tumor and has high contrast. Now we will try to find this region by gray1 and gray2. When we use the gray1= 0.0021 and gray2= 0.1171 as shown in fig.7(a) the result image of ROI1 is very brightness so much so that all the data hidden as shown in fig 7(b).

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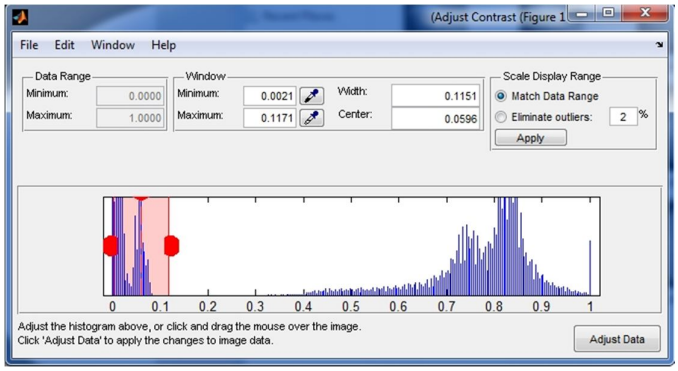
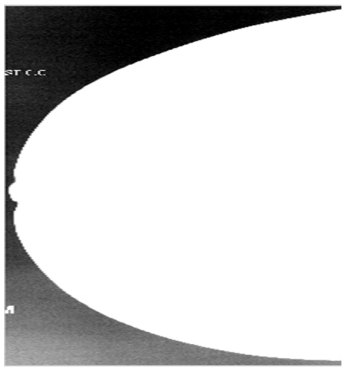
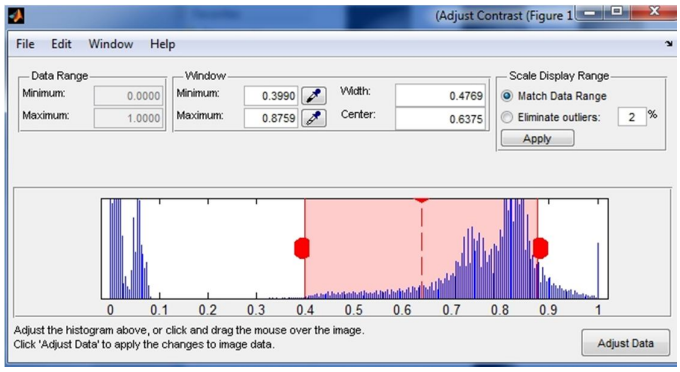


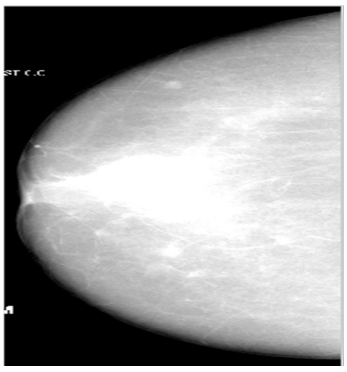


(a) target figure with gray1= 0.0021 and gray2=0.1171 (b) result image

Fig:7 image contrast analysis to select ROI1

When we use the gray1= 0.399 and gray2= 0.8759 as shown in fig: 8 (a) the result image of ROI2 is better than the previous, but the tumor is still unclear as shown in fig: 8 (b).

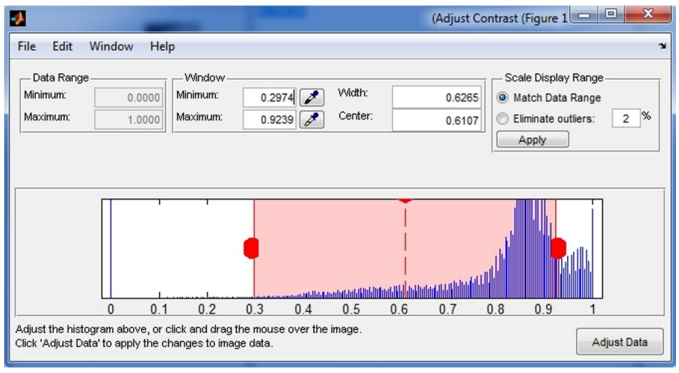


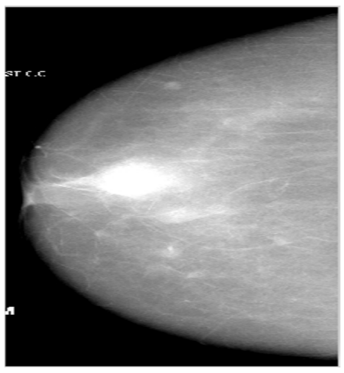


(a) target figure with gray1= 0.399 and gray2=0.8759- (b) result image

Fig:8 image contrast analysis to select ROI2

When we use the gray level from 0.2974 to 0.9239 as shown in fig: 9 (a) the result image of ROI3 is better than the previous, and the tumor is clear as shown in fig: 9 (b).

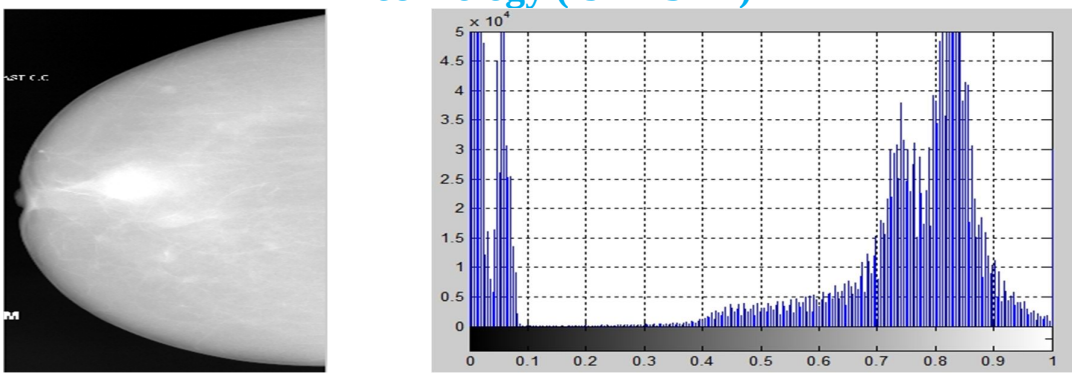




(a) target figure with gray1= 0.500 and gray2=0.9817 (b) result image

Fig:9 image contrast analysis to select ROI3

Now we found the ROI between gray1=0.2974 and gray2= 0.9239 and to save this image we used dicomwrite function. This Step is finally step of preprocessing stage as shown in Fig. 10.



(a) (b)

Fig. 10: (a) image after prepressing stage , (b) its histogram

B. Noise Removal

The second stage of proposed algorithm is a noise removal, which aims to reduce the noise of images. Medical images are subject to a wide variety of distortions during processing, compression, re-production, storage, acquisition and transmission, any of which may result in a degradation of visual quality. Images such as, computed tomography, ultrasound magnetic resonance imaging, and X-ray images are collected by different types of sensors and they are contaminated by different types of noises. Noises involve Gaussian noise and speckle noise. Normally, low quality images are not effective and very difficult to measure so there is an important need of noise reduction form medical images [7].We reduced noise from the images by two steps. Firstly we add tow type of noise with different variance to image because the noise of the original image does not appear. Secondly noisy images are passing through different filters. Selecting the best filter which produces the best results depends on its parameter.

1) *Generation of Noisy Image:* Although speckle noise and Gaussian noise can appear superficially similar in an image, they are a result of different processes and need different approaches for their removal. Whereas Gaussian noise can be modeled by random values added to an image speckle noise can be modeled by random values multiplied by pixel values, so it is also called multiplicative noise [8]. If the only degradation present in an image, g(x, y), is additive noise then

$$g(x,y) = f(x,y) + n(x,y) \quad \text{Equation (1)}$$

When an image, f (x, y), is contaminated by multiplicative or speckle noise then

$$g(x,y) = f(x,y) * n(x,y) \quad \text{Equation (2)}$$

Where f(x, y) is the original and n(x, y) is the noise. To add the noise to the image, IPT function imnoise is used for this task

2) *Denoising Techniques:* Filtering is a second step of noise removal which is a technique for enhancing or modifying an image. For example, you can filter an image to remove other features or emphasize certain features. Image processing operations implemented with filtering involve sharpening, edge enhancement and smoothing. Filtering is a neighborhood operation, in which the value of any given pixel in the output image is determined by applying some algorithm to the values of the pixels in the neighborhood of the corresponding input pixel. A pixel's neighborhood is some set of pixels defined by their locations relative to that pixel linear filtering in which the value of an output pixel is a linear combination of the values of the pixels in the input pixel's neighborhood [9]. In this study we used three types of filter as follows.

3) *Gaussian Filter:* The Gaussian filter is a very important one both for theoretical and practical reasons. Here, we filter the image using a discrete kernel derived from a radially symmetric form of the continuous 2-D Gaussian function defined as follows:

$$F(x,y) = \frac{1}{2\pi\sigma 2} exp\left(-\frac{x^2+y^2}{2\sigma^2}\right) \quad \text{Equation (3)}$$

Applying the Gaussian filter has the effect of smoothing the image, but it is used in a way that is somewhat different to the mean filter. The degree of smoothing is controlled by the choice of the standard deviation parameter σ, not by the absolute value of the kernel size [10].

a) *Median Filtering:Median* filtering corresponds to a nonlinear smoothing filter which is used to reduce random noise. This smoothing filtering in particular was tested as it allows further edge preservation, when compared with the others smoothing filtering. This filtering ranks the image pixels in a certain neighbor of a central pixel and replaces the value of this by the median of the neighborhood [11].

b) *Wiener Filter:* The Wiener filter (developed by Norbert Wiener in 1942) is an image restoration solution that can be applied to images that have been subject to a degradation function and also contain noise, The design of the Wiener filter is guided by an attempt to model the error in the restored image through statistical methods, particularly the minimum mean square estimator: once the error is modeled, the average error is mathematically minimized. Assuming a degraded version g(x, y) of some original image f (x, y), and a restored version r(x, y), if we compute the sum of the squared differences between each and every pixel in f (x, y) and the corresponding pixel in r(x, y), we have a figure of merit that captures how well the restoration algorithm worked smaller values mean better results .The transfer function of a Wiener filter is given by [10]

$$R(u,v) = \left[\frac{1}{H(u,v)}\frac{|H(u,v)|2}{|H(u,v)|2+K}\right]G(u,v) \quad \text{Equation (4)}$$

Where H (u, v) is the degradation function and K is a constant used to approximate the amount of noise. When K = 0equation (4) reduces to equation (5).

$$R(u,v) = \frac{G(u,v)}{H(u,v)} \quad \text{Equation (5)}$$

4) *Image Quality Evaluation Parameters:* The Peak Signal to Noise Ratio (PSNR) and the Mean Square Error (MSE) are the two error metrics used to compare image compression quality [6].

a) *Mean Square Error (MSE):* MSE represents the cumulative squared error between the compressed and the original image .the lower the value of MSE, the lower the error. It is mathematically defined as [6]:

$$MSE = \frac{1}{m*n}\sum_{m,n}[(i,j) - F(i,j)^2] \quad \text{Equation (6)}$$

Where m is the number of row in the image, n is the number of column in the image, I (i, j) is noisy image and F (i, j) is de-noised image

b) *Signal To Noise Ratio:* PSNR represents a measure of the peak error and it is mathematically described as: [6]

$$\text{PSNR} = 10\log_{10}\left(\frac{R^2}{MSE}\right) \quad \text{Equation (7)}$$

$$\text{PSNR} = 20\log_{10}\text{R} - 10\log_{10}\text{MSE} \quad \text{Equation (8)}$$

R is the maximum possible pixel value in the input image data type [6]. Higher value of PSNR of de-noised and original image implies that the performance of the de-noising filter method and visual quality of the de-noised image is good [7].

C. *Enhancement Of Digital Mammogram:* The final step of our proposed algorithm is to enhance of the dicom images by using a different image enhancement techniques which are a group of image processing methods that could enhance digital images to make better visualization for radiologists. Previous research showed that some enhancement techniques, i.e. histogram stretching, histogram equalization and CLACH can increase the early detection of breast tumor [12] these techniques mostly affect the image contrast. These techniques are discussion in the following section.

1) *Contrast Limited Adaptive Histogram Equalization (CLAHE):* Contrast limited adaptive histogram equalization (CLAHE) technique is a special case of the histogram equalization technique. The CLAHE operates on small regions in the image called tiles rather than the entire image. Each contrast of tiles is enhanced, so that the histogram of the output region approximately matches the uniform distribution or Rayleigh distribution or exponential distribution. Distribution is the desired histogram shape for the image tiles. The neighboring tiles are then combined using bilinear interpolation to eliminate artificially induced boundaries. The contrast, especially in homogeneous areas, can be limited to prevent amplifying any noise and reduce edge-shadowing effect that might be present in the image [13].we used adapthisteq function to do this task.

2) *Histogram Stretching:* The contrast between the object (abnormal area) and its background (normal tissue) increases by histogram stretching. It means that the maximum pixel value would change to 255 (white) and the minimum pixel value would change to 0 (black), and all other values would stretch between these two. The difference between target object and background is increased by this procedure [8 14]. We used imadjust function to increase the image contrast as shown in following command.

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g = imadjust (I, stretchlim (g, [0.44 0.999]) command

Where stretchlim is a function used to find limits to contrast stretch image and we get 0.44 and 0.999 by using a try and error method to get the best result of image enhancement.

III. RESULTS AND DISCUSSION

The results presented in table1 are MSE and SPNR of Gaussian noisy image with different variance and filtered it by Gaussian, median and wiener filter .the relation between them is shown in fig11. Based on these results the wiener filter is the best one of them because it has the highest PSNR and the lowest MSE.

Table 1: image quality parameters after applying Gaussian noise and filtered the image

Variance of noise	Gaussian filter		Median filter		Wiener filter	
	MSE	PSNR	MSE	PSNR	MSE	PSNR
0.01	0.0058	22.3596	0.0077	21.115	0.00417	23.306
0.05	0.0226	16.4541	0.0315	15.021	0.0179	17.4812
0.1	0.0391	14.0756	0.0559	12.524	0.0309	15.0996

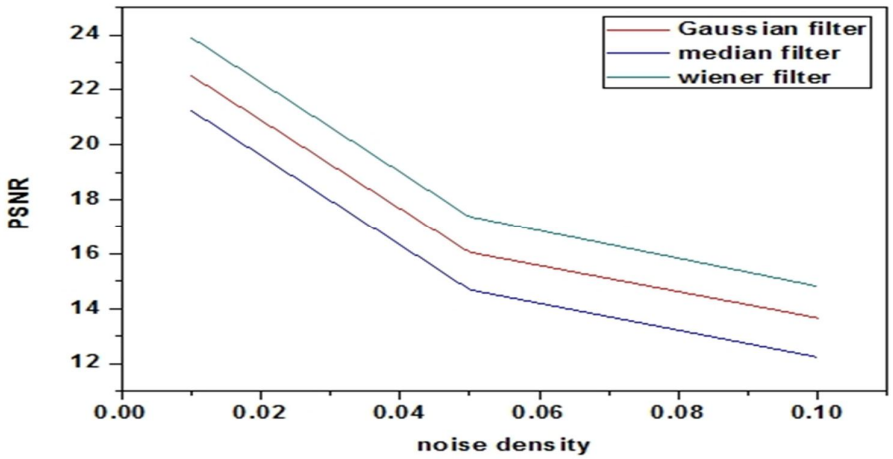
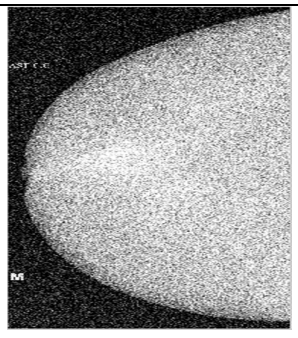
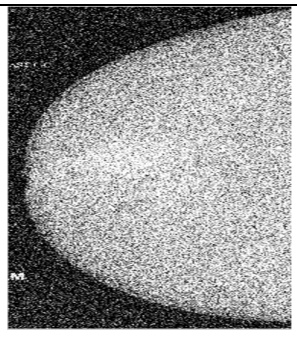


Fig. 11: The relation between PSNR and Noise Density of Gaussian image

Fig: 12 shows the results of adding Gaussian noise with different variance to the image and filtered it by Gaussian, median and wiener filter.

			
Noise density	0.01	0.05	0.1

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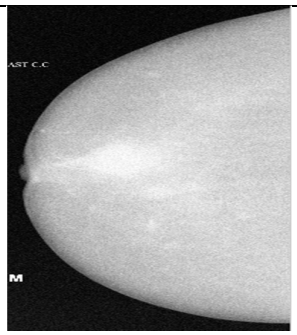
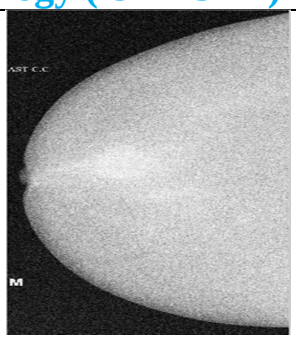
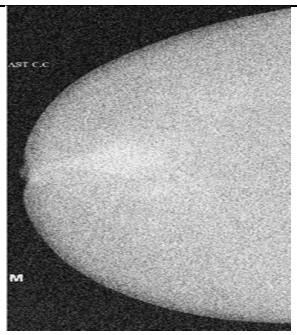
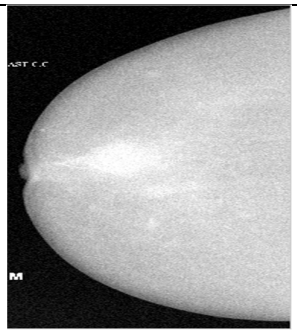
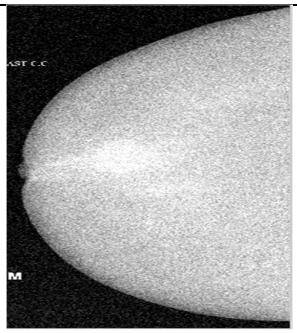
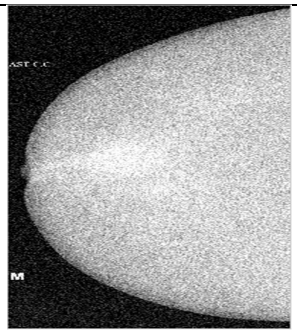
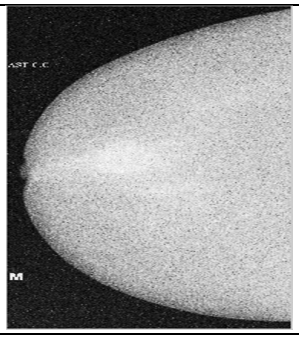
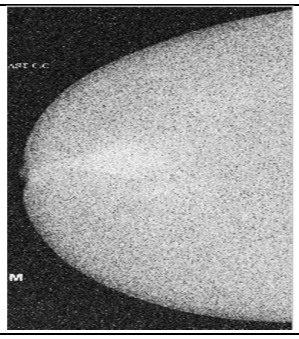
Gaussian filter			
Median filter			
Wiener filter			

Fig 12: The image after applying Gaussian noise and filtered it.

The results presented in table2 are MSE and SPNR of speckle noisy image with different variance and filtered it by Gaussian, median and wiener filter .the relation between them is shown in fig13. Based on these results the wiener filter is the best one of them because it has the highest PSNR and the lowest MSE.

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Table 2: image quality parameters after applying speckle noise and filtered the image

Variance of noise	Gaussian filter		Median filter		Wiener filter	
	MSE	PSNR	MSE	PSNR	MSE	PSNR
0.01	0.0031	25.1102	0.0041	23.8965	0.0019	27.184
0.05	0.0124	19.0604	0.0172	17.6332	0.0074	21.3066
0.1	0.0214	16.7058	0.0305	15.1564	0.0127	18.9669

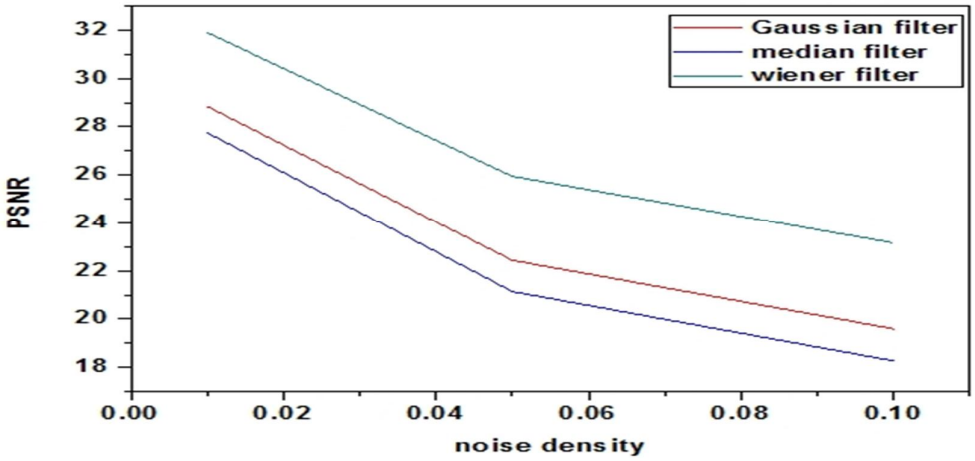
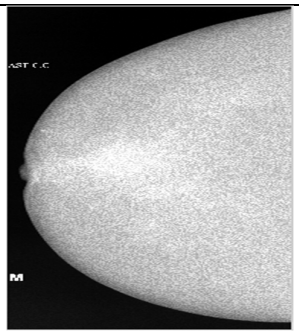
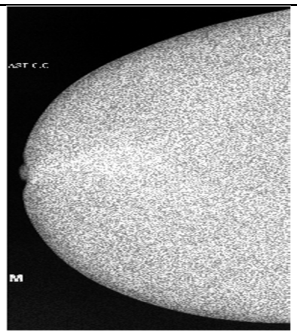
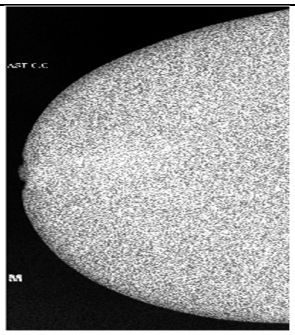


Fig. 13: The relation between PSNR and Noise Density of speckle noisy image

Fig: 14 show the results of adding speckle noise with different variance to the image and filtered it by Gaussian, median and wiener filter

			
Noise density	0.01	0.05	0.1

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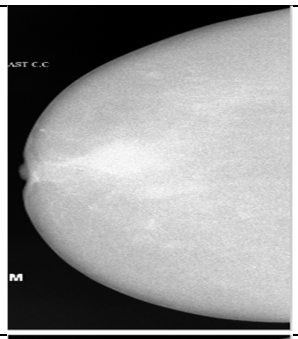
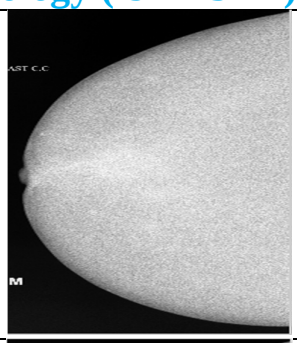
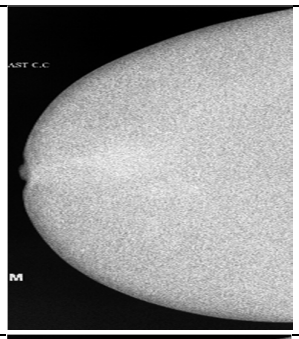
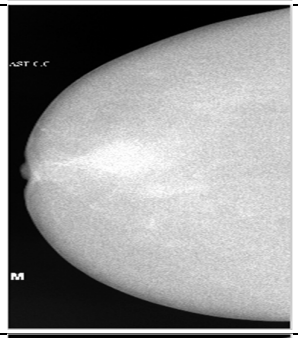
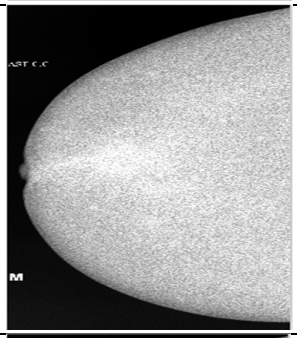
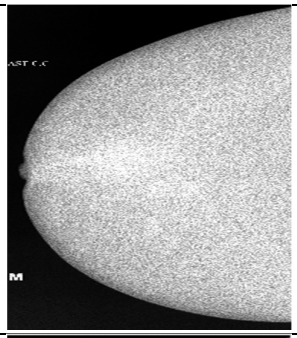
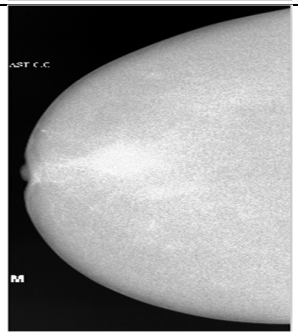
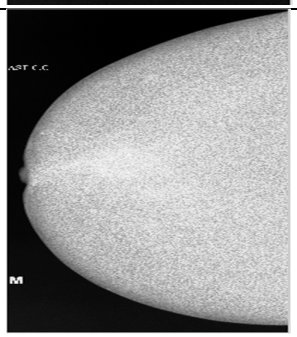
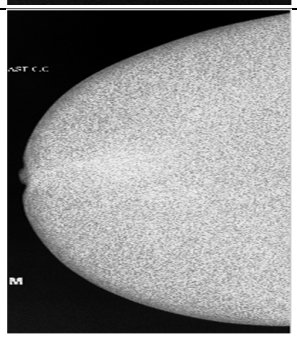
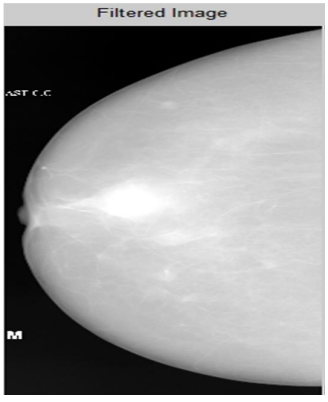
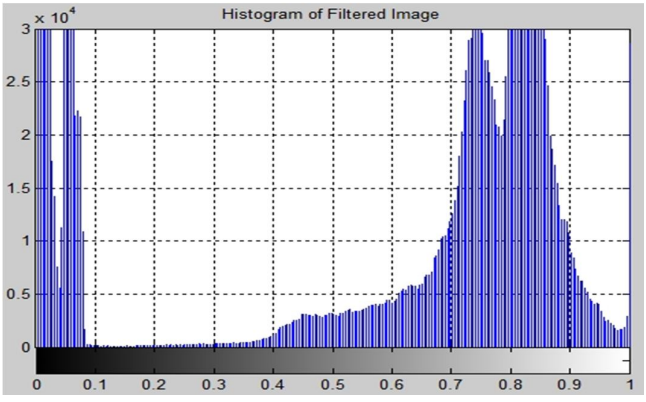
Gaussian filter			
Median filter			
Wiener filter			

Fig 14: The image after applying speckle noise and filtered it.

From the comparison tests that results shown in Table 1 and table 2 we see the PSNR and MSE for every filter, the results show that the wiener filter has the highest PSNR and lowest MSE.so the images are passing through it as shown in fig. 15 because it is suitable for the most of noises forms. After that we enhance the contrast of image by enhancement techniques.





(a) (b)

Fig. 15: (a) filtered image by wiener filter , (b) its histogram

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Fig. 16 shows the enhancement results of CLAHE on image with different tile sizes. Different tiles were tested, however, only tiles 8x8 ,16x16 and 32*32 pixels are presented in Fig. 16(a) , (c) and (e), each tile pixels was enhanced by matching a uniform histogram distribution .this technique improved the contrast of the tumor however, introduced some noise to the image due to the enhancement of the fibro glandular tissue surrounding the tumor.

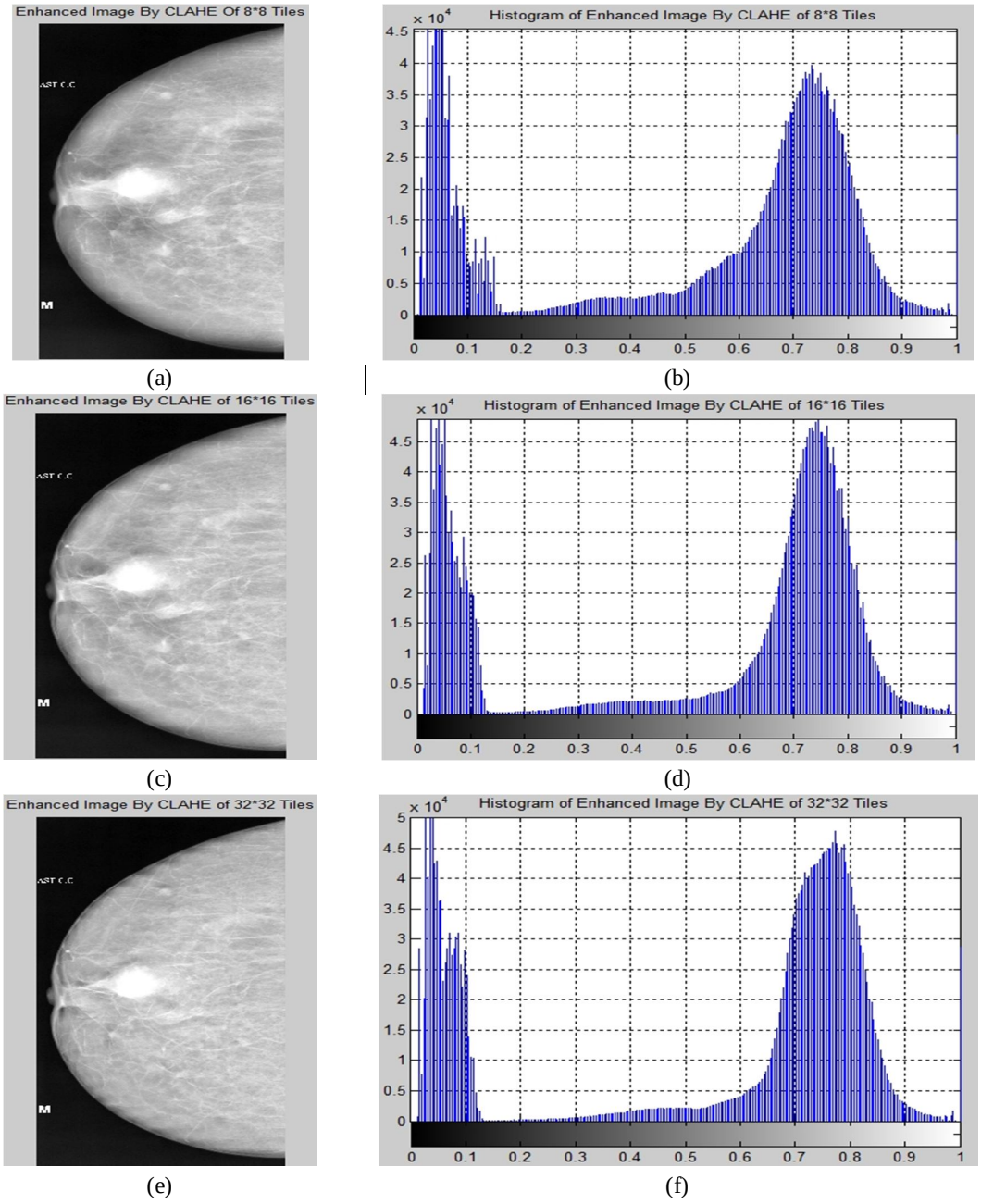
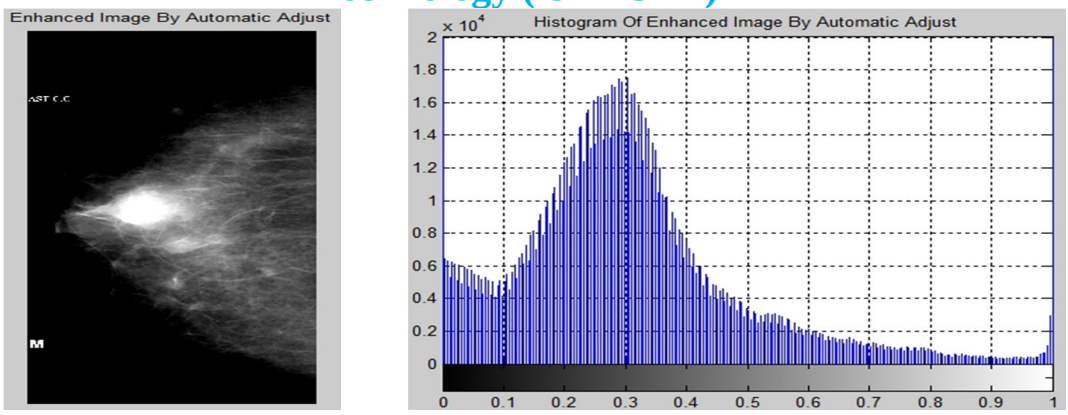


Fig.: 16 the Results of CLACH technique (a) image after CLACH (8*8 tiles) and(b) its histogram, (c) image after CLACH (16*16 tiles) and(d) its histogram and (e) image after CLACH (32*32 tiles) and(f) its histogram

Fig.17 shows the enhancement result by the contrast stretching on image. , this technique improved the image contrast as shown in Fig. 17 (a) when compared with the image after prepressing stage as shown in Fig. 10 (a) and it is the best technique of image enhancement.



(a) (b)

Fig. 17: (a) enhanced image and (b) its histogram by automatic adjust.

IV. CONCLUSIONS

In our method a digital medical image processing uses denoising and image enhancement techniques to reveal any tumors that may not be obvious and to improve the image quality of DICOM breast image such that the resulting image is better than the original. Also from the above study wiener filter is suitable for the noise removable and histogram stretching increase image quality for detection of tumor this is a pilot study, but it is hoped that these methods could provide better visualization for detection of tumor in digital mammograms.

V. FUTURE WORK

In the future we will develop an algorithm for breast segmentation also breast tumor extraction and breast tumor analysis.

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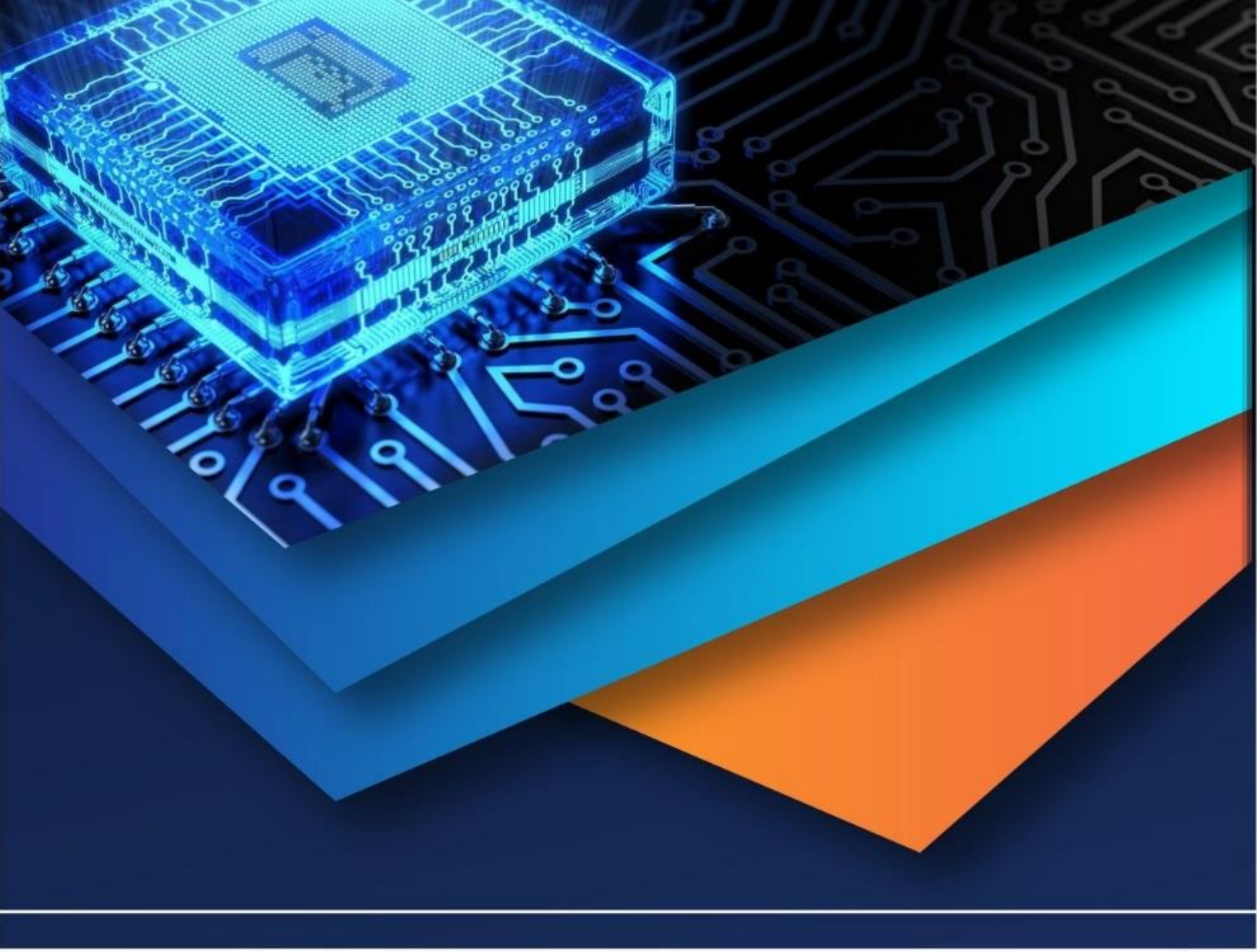

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