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Research Article

Gaussian Fuzzy Membership Function for Enhancement of Different Medical Images

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Abstract: Disease is a cause which originates the need of treatment, whenever there is any kind of suspicion, person tends to visit specialist for diagnose. Diagnose of disease tissues is crucial task in order to take right decisions for treating and preventing disease at right time. Several researches shows that if disease is diagnosed at early stage, it will decrease the rate of morality and options of treatment will be increased. In thispaper an efficient approach for enhancement of medical images is proposed. This approach is based on Gaussian fuzzy technique. Gaussian fuzzy approach uses Gaussian fuzzy membership function for enhancing medical images. This approach uses average gray level values and threshold to find bandwidth of Gaussian function, this bandwidth in turn is used in general formula for Gaussian function. Using this function, we obtain enhanced image as an output. Medical images from standard database are obtained and carried out through experimentation process. For efficient testing different medical images (MRI, CT-SCAN, X-RAY and Mammograms etc.) are extracted from database. Obtained results are compared with the results from other techniques and the results from the proposed approach are quite promising and when compared proposed approach comes out to be better than previous approach. This approach can be used to develop Computer-Aided decision system for detection of diseases in future.
Keywords: Medical Image Enhancement, Gaussian Fuzzy Membership Function, Threshold

Introduction

Image enhancement is a process which possess many other techniques which are used to enhance the visualization of the image for human analysis [1]. Motto of image enhancement is to process the given image to produce other image with desired results. All medical images have different dimensions due to different densities of disease tissues and variation in shape and size of affected body parts, this makes medical images fuzzy in nature. Due to this working with medical images is a complex process and should be carried out with lot of attention so that the information carried by medical image is not damaged, because that information is of great use in the process of diagnosis [3]. Fuzzy nature of medical images leads to raise the necessity of fuzzy image processing. Fuzzy image processing uses fuzzy sets [2], [7] for handling such problems. Fuzzy sets are different from basic sets. Elements of fuzzy set can have complete or partial belongingness to the set. Every element is characterized with its membership function, which decides that where in between [0-1] the element lies. One of the important aspect in handling medical images is amount of enhancement to be done, reason behind is delicate nature of disease tissues. Too much of enhancement will lead to merging of tissues with the background which will result in false detection and too little enhancement will rule out the detection. These false-positive and false-negative results cause problem for specialist/doctors in reading medical images [4]. False-positive results are those which are proved to be disease tissues but in actual they were nothing but merged background tissues [8]. Other issue is false-negative results. False-negative were actually the disease affected areas which were left unidentified due to lack of proper visibility of the medical images [6]. In past years several efforts are made in diagnosing diseases by studying medical images, but the inspection by different doctors is a costly and time consuming process. Automatic detection of diseases with the help of computer system is one of the solution for the problem.

From the past researches made in this area of medical image enhancement few are discussed here. In 1998 Woods and Runge [11] have worked on 3D MRI images in 2 phases, in first phase he removed noise and highlighted edges and in second phase sigma filters were used to obtain refined results. He performed smoothing and reformatting of MRI images. In 2012, Yasmin *et al.*[12] carried out his research on enhancement of brain images. He studied MRI and CT for removal of noise and enhancement, filtering and smoothing techniques were used. Bhardwaj *et al.* [3] used wavelet transformation for enhancement of medical images for de-noising he used threshold using shrink method, Haar and wavelet transformations were used for enhancement. In 2013 Mohanapriya and Kalaavathi [13] have compared different enhancement methods for enhancing medical images. Gray level transformation and other special techniques were carried out on X-ray images, CT-Brain and Ultrasound images. Farbiz *et al.* [7] used iterative method for image enhancement. Fuzzy logic was introduced in this process. In 2012 Jiang *et al.* [8] put forward method to enhance medical images using combination of image detail preservation and bi-dimensional empirical mode decomposition with histogram equalization. Hassanpour *et al.* [14] introduced new technique for contrast enhancement of medicalimages. Morphological transformation was used. WANG *et al.* [15] proposed algorithm based on GSM model for wavelet coefficients and claimed that approach produces better results and preserves quality. CT images were used for testing. In 2012 Khehra *et al.*[16] proposed approach for automatic detection of microcalcification in digitized mammograms. Fuzzy 2-partition entropy along with mathematical morphology was used. Research was carried out in 2 phases, in first phase mammograms were fuzzified and using fuzzy 2-partition entropy bandwidth of Gaussian function was found and in second phase using mathematical morphology. Microcalcifications are differentiated from the background and Otsu's threshold selection method is used to locate microcalcifications in mammograms.

In this paper efficient approach for medical image enhancement using Gaussian fuzzy membership function has been made. Image fuzzification is done using Gaussian membership function; for finding bandwidth of Gaussian function 2 parameters are used which are: Average gray level value(K) and Threshold $(T)$for the input image $f(x,y)$. With the help of formula for Gaussian membership function and using bandwidth; input image/ original image $f(x,y)$ is enhanced and a new enhanced image $g(x,y)$ is obtained. In order to validate efficiency of the approach experiment has been conducted on medical images that have been taken from mini-MIAS database and histogram of original and enhanced images are obtained.

The rest of this paper is elaborated as follows: Section 2 explains proposed approach for enhancement of medical images; In Section 3 experimental results are discussed and paper is concluded in Section 4.

Proposed Methodology

In proposed approach Gaussian fuzzy membership function based approach is developed to enhance medical images. Different aspect of medical images like different disease symptoms, shape, size and dimensions are the reasons due to which medical images are fuzzy in nature. To handle fuzzy nature of medical images fuzzy sets are used.

Image fuzzification

Medical images are converted from gray level plane to membership plane i.e. fuzzy domain [18,19]. Due to fuzzy nature of disease tissues fuzzy sets are chosen to deal with uncertainty contrast of disease tissues varies due to presence of surrounding tissues and different shape and size of body parts. Choosing fuzzy logic is a right decision in this field. Gaussian membership function is one which is used very often for converting medical images in to fuzzy domain [17], [20]. Figure 1 represents Gaussian membership function graphically.

Standard Gaussian membership function for enhanced images is defined as:

$$g(x,y) = e^{-\frac{[f(x,y) - L_{max}]^2}{2b^2}} \quad (1)$$

Where:
L_{max} :max. gray level of input medical image.
b:bandwidth of Gaussian function
$f(x,y)$:input medical image
$g(x,y)$:fuzzy image

Bandwidth of Gaussian membership function is defined as:

$$b = \max\{(T-K),(L_{max} - T)\} \quad (2)$$

K is average gray level of input medical image and T is threshold of input medical image. Our target is to enhance suspicious region and suppress background. Suspicious region can be identified with the help of threshold.

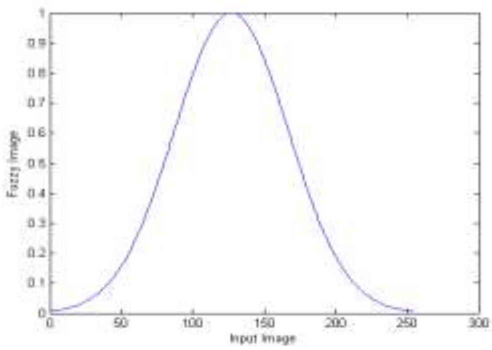


Fig-1: Graph for Gaussian membership function

Selection of parameter K for bandwidth of Gaussian function

Average gray level value can be obtained by calculating gray level values in the image and dividing them by total no. of pixels in the image each pixel in the image is allocated gray level [5]. Gray level varies between 0-255. Summation of gray levels of all the pixels is calculated using formula. Average gray level value is denoted by *'K'* and formula for calculated average gray level value is given by:

$$K = \frac{1}{n}\sum_{x=1}^{M}\sum_{y=1}^{N} f(x,y) \quad (3)$$

Where:
M and *N*: size of medical image/dimensions
n: total no. of pixels
$f(x,y)$: input medical image

Algorithm for finding parameter K (Algorithm-1)

Algorithm for finding the average value of gray level in the medical image which is represented by K is elaborated step by step below:

Step 1: Read input image that is denoted by $f(x,y)$.

Step 2: Calculate size of input image which is denoted by *[M×N]*, where *M* represents number of rows and *N* represents number of columns.

Step3: Find the total number of pixels using following equation:

$$n = [M \times N] \quad (4)$$

Where *n* denotes number of pixels.

Step 4: Find sum of gray level values of all pixels in the medical image by the equation which is denoted as follow:

$$Sum = \sum_{x=1}^{M}\sum_{y=1}^{N} f(x,y) \quad (5)$$

Step 5: Average is calculated using following formula:

$$Average\ (K) = \frac{Sum}{n} \quad (6)$$

Step 6: Stop.

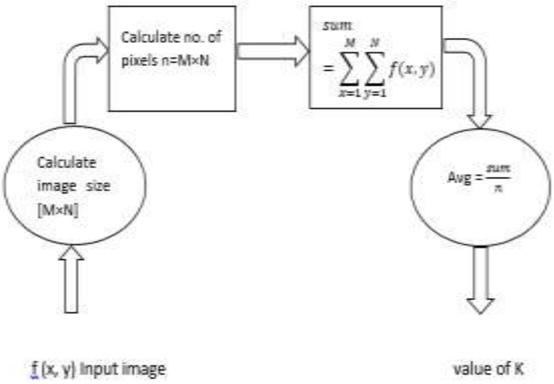


Fig-2: Flow Diagram

Selection of parameter T for bandwidth of **Gaussian function**

Parameter T has an important role in determining bandwidth for the Gaussian function. With the help of best selected bandwidth for Gaussian function disease tissues or target area is enhanced in medical image and other regions are suppressed. T is the threshold which is used to diminish background and enhance suspicious region. Threshold values are those values which helps in detecting the suspicious region out of the input image [21]. The action performed or the signal that passes out of the threshold limit is said to be suspicious or something is happened, so value to T plays an important role in determining bandwidth.

Algorithm for finding T (Algorithm-2)

Algorithm for finding the threshold value for the medical image which is represented by T is elaborated step by step below:

Step 1: Read input image that is denoted by $f(x,y)$.

Step 2: Initialize threshold value say *T*.

Step 3: Input image $f(x,y)$ is divided into two parts:
Target region (*TR)* and Background image *(BR)*

$$TR\ (x,y) \in f(x,y) \geq T \quad (7)$$

$$BR\ (x,y) \in f(x,y) < T \quad (8)$$

Step 4: Find average gray level of *TR* and *BR* which is represented as μ_{TR} and μ_{BR} respectively.

Step 5: Find new threshold value

$$T = \frac{\mu_{TR} + \mu_{BR}}{2} \quad (9)$$

Step 6: Repeat step 3 until difference between old and new threshold is ≤ *C*; where *C* is constant factor i.e. close to zero.

Step 7: Stop.

After finding both parameters T and K, i.e. threshold and average gray level value, bandwidth b is calculate using these two parameters. Bandwidth is then used along with the max. gray level value i.e. L_{max} (which will be calculated separately), to find the enhanced image $g(x, y)$.

Algorithm for finding Enhanced image g(x, y)

Algorithm to find enhanced image which is denoted by $g(x, y)$, is explained below step by step:

Step 1:Read input image denoted by $f(x, y)$.

Step 2:Find Max. Gray level value of input image $f(x, y)$, which is represented as: L_{max} .

Step 3:Find Average Gray Level value K using Algorithm-1.

Step4:Find Threshold value T using Algorithm-2.

Step 5:Find Bandwidth b using equation 4.2, formula for finding Bandwidth is as follows:

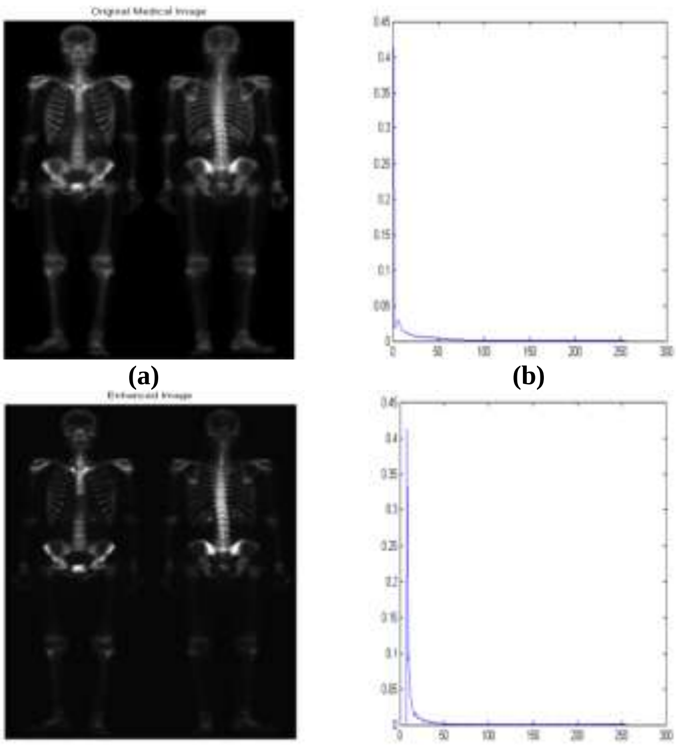
$$b = \max\{(T - K), (L_{max} - T)\} \quad (10)$$

Step6:Enhance input image (x, y) , using equation (1) and is represented as follows:

$$g(x, y) = e^{-\frac{[f(x,y) - L_{max}]^2}{2b^2}} \quad (11)$$

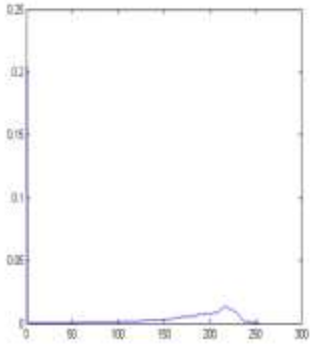
Experimental Results and Discussion

In this section efficiency of proposed approach is calculated from the results obtained using MATLAB 7.7.0 against number of medical images having disease tissues. Number of different medical images having disease tissues are obtained from standard database. For obtaining refined results different type of medical images are considered and processed. Standard images which are named as 'Bone-Scan', 'Chest', 'Head-CT', 'Lung', 'MRI-Knee', 'MRI-Spine', 'PET', 'Benign-mammogram' , 'Malignant' are used and their sizes are (800×500), (493×600), (512×512), (976×1252), (388×462), (512×512), (116×746), (256×256), (256×256) respectively. Original Standard test medical images are displayed in Figure 3-11 respectively. Values of parameters K (average gray level value) and max. gray level values are represented through Table-1. And values for parameter T (threshold) which further helps in finding bandwidth of Gaussian membership function are displayed in Table-2.

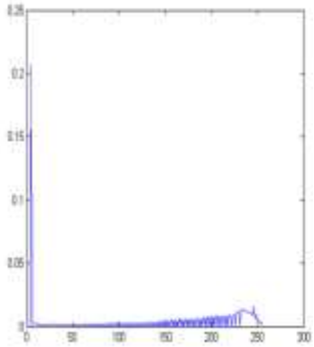


(a) **(b)** **(c)** **(d)**

Fig-3: (a) Original bone-scan Image, (b) Histogram of an Image, (c) Enhanced Image (d) Histogram of Enhanced Image

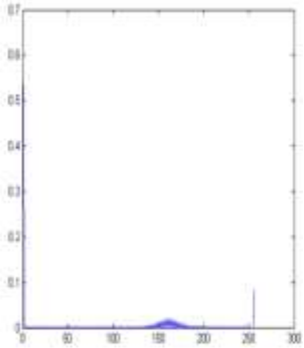



(a) **(b)**

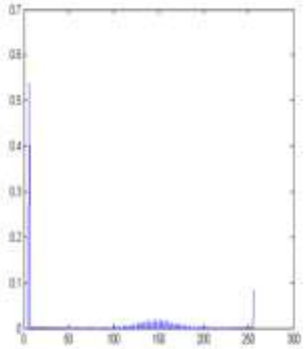



(c) **(d)**

Fig-4: (a) Original Medical Image of Chest, (b) Histogram of an Image, (c) Enhanced Image and (d) Histogram of Enhanced Image

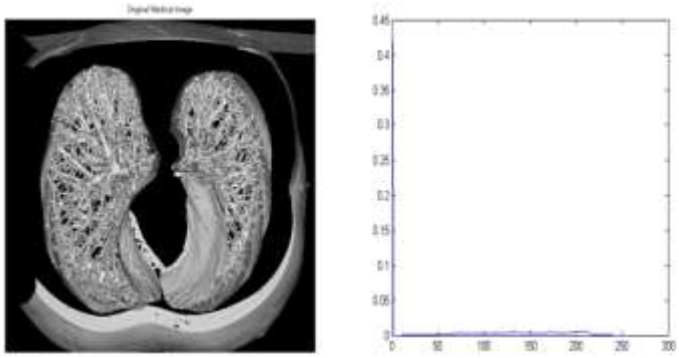



(a) (b)

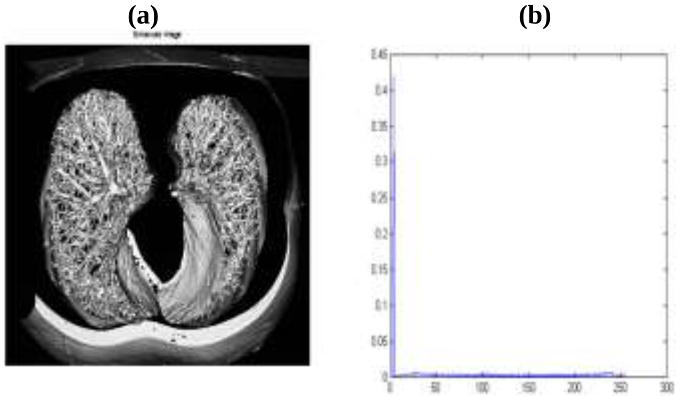



(c) (d)

Fig-5: (a) Original Head-scan Image, (b) Histogram of an Image, (c) Enhanced Image and (d) Histogram of Enhanced Image

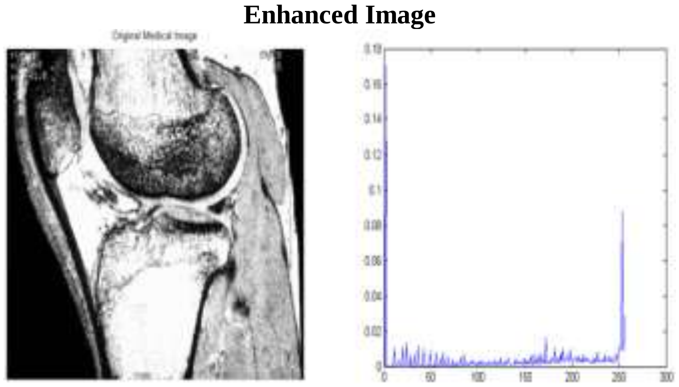


(a) **(b)**

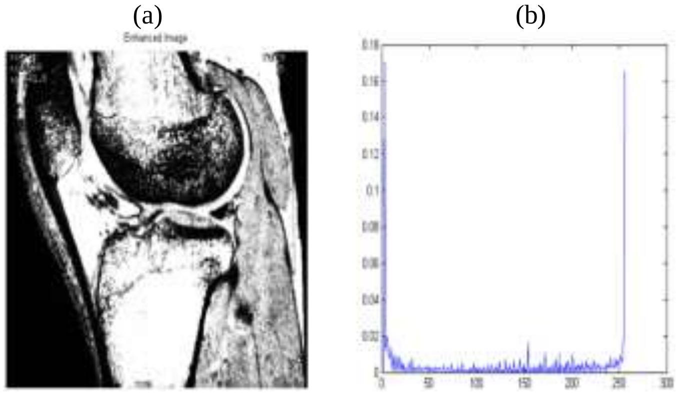


(c) **(d)**

Fig-6: (a) Original Medical Image of Lung, (b) Histogram of an Image, (c) Enhanced Image and (d) Histogram of Enhanced Image

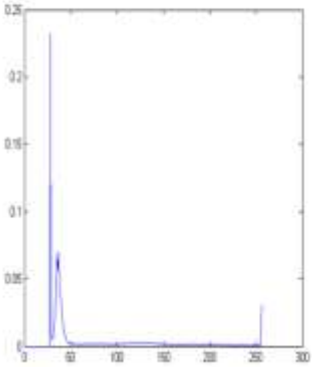


(a) (b)

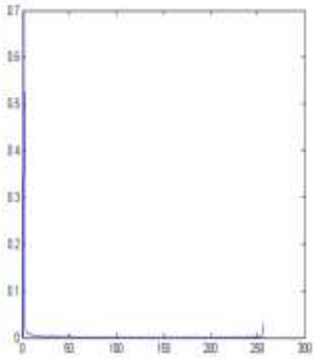


(c) (d)

Fig-7: (a) Original MRI of Knee, (b) Histogram of an Image,(c) Enhanced Image and (d) Histogram of Enhanced Image

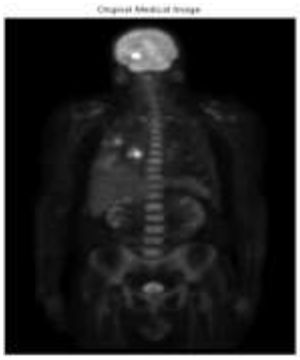
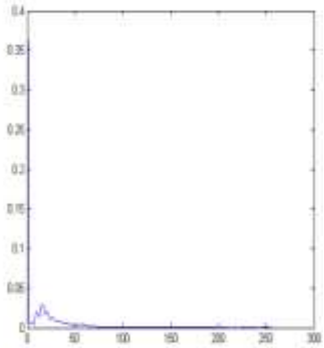



(a) **(b)**

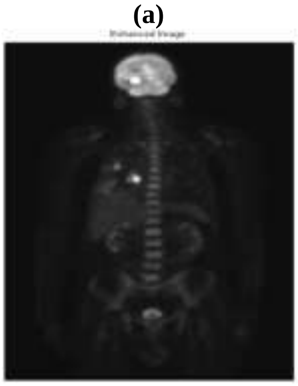
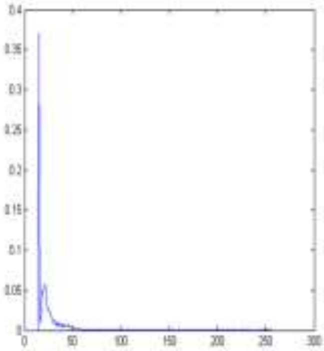



(c) **(d)**

Fig-8: (a) Original MRI-Spine, (b) Histogram of an Image, (c) Enhanced Image and (d) Histogram of Enhanced Image

(a) **(b)**

(c) **(d)**

Fig-9: (a) Original Image of PET, (b) Histogram of an Image, (c) Enhanced Image and (d) Histogram of Enhanced Image

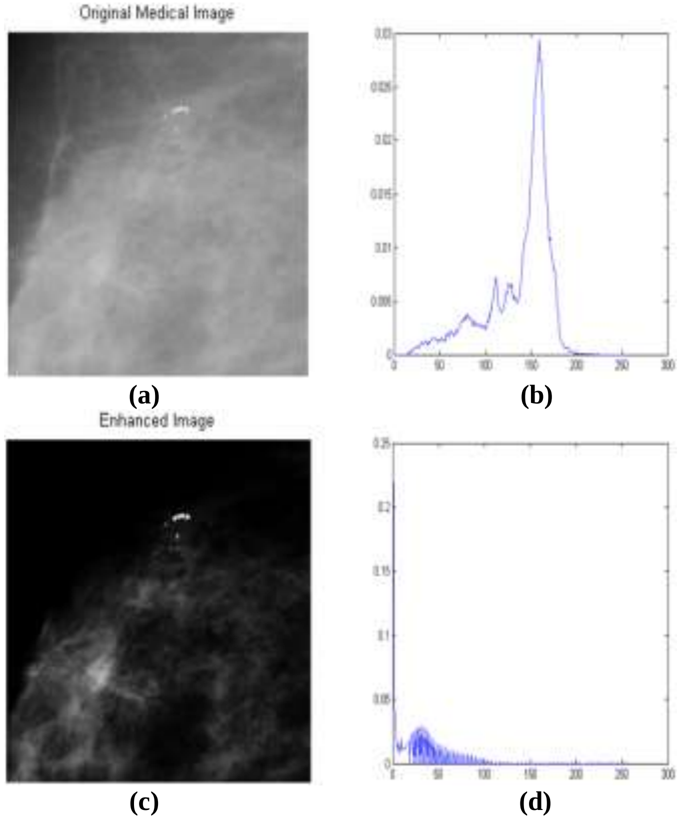


Fig-10: (a) Original Image of Benign mammogram, (b) Histogram of an Image, (c) Enhanced Image and (d) Histogram of Enhanced Image

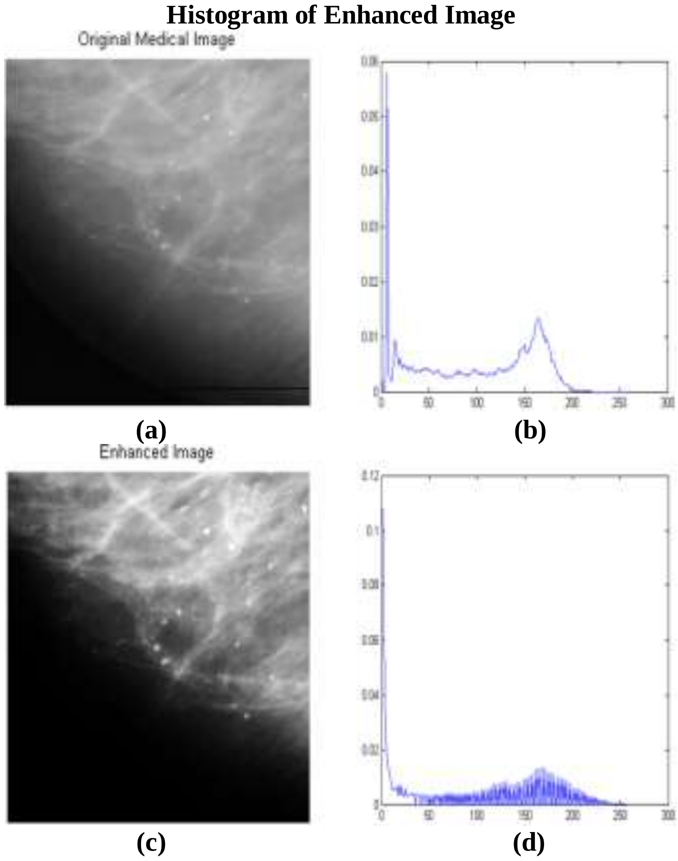


Fig-11: (a) Original Image of Malignant, (b) Histogram of an Image, (c) Enhanced Image and (d) Histogram of Enhanced Image

Table- :1Average gray level values and max. gray level values for finding bandwidth

S.No	Test Image	Avg. Gray Value (*K*)	Max. gray level value
1.	Bone-scan (800×500)	138	255
2.	Chest(493×600)	190	253
3.	Head-CT(512×512)	181	255
4.	Lung(976×1252)	164	238
5.	MRI-Knee(388×462)	204	255
6.	MRI-Spine(512×512)	173	255
7.	PET(1162×746)	149	255
8.	Benign Mammogram(256×256)	149	222
9.	Malignant mammogram(256×256)	152	219

Table-2:Threshold values for finding suspicious region and enhancing medical image using bandwidth and Gaussian membership function

S.No	Test Image	Threshold (*T*)
1.	Bone-scan (800×500)	42
2.	Chest(493×600)	103
3.	Head-CT(512×512)	91
4.	Lung(976×1252)	85
5.	MRI-Knee(388×462)	121
6.	MRI-Spine(512×512)	108
7.	PET(1162×746)	43
8.	Benign Mammogram(256×256)	118
9.	Malignant mammogram(256×256)	92

Conclusion and Future Scope

Several years of study in the area of medical imaging had put forward many different approaches to enhance medical images.In this paper, an effort is made to propose an efficient approach for enhancement of medical images and finding suspicious region from the medical image with disease tissues. Gaussian fuzzy technique is used to enhance medical images. To evaluate the efficiency of proposed approach experiment have been conducted on different medical images taken from standard database (X-Ray, MRI, Ct, Mammograms). Testing medical images are worked out using proposed approach and the results obtained shows the efficiency and simplicity of the approach. Proposed approach can be useful for radiologist and other specialists for detection of diseases and it can be used in developing computer-aided system for early disease-detection.

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