ADAPTIVE MEAN SHIFT MODIFIED EXPECTATION MAXIMIZATION (AMS MEM) FRAMEWORK FOR BREAST MRI SEGMENTATION

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ABSTRACT

Breast cancer is found to be the most common form of cancer found in women which is the leading cause for cancer death worldwide. Detection of abnormality at the earliest increases the chances of successful treatment and can reduce the mortality rate. MRI is a widely used medical imaging technique. Noise in MRI negatively affects image processing and analysis works. The main objective of preprocessing stage is to improve the quality of image by removing the irrelevant noises and unwanted portions in the image so as to convert the image into some other representation that is more meaningful, thus making it easier to interpret the details in an image. In this proposed work various filtering algorithms are discussed and compared and an automated scheme for Magnetic Resonance Imaging (MRI) breast segmentation is proposed.

Keywords* — *Breast cancer, Filtering Algorithms, Preprocessing, Segmentation

I. INTRODUCTION

Breast cancer is found to be the most common form of cancer affecting the woman nowadays. Breast cancer is the uncontrolled growth of cells in the breast region. It is the primary cause of cancer death in women, after lung cancer. The estimated New Female Breast Cancer Cases and Deaths by Age during 2015 In Situ Cases Invasive Cases Deaths is about 40,290 for all cases**.** Detection and diagnosis of breast cancer at the earliest increases the chances for successful treatment and complete recovery of the patient. The dimensions and weight of the breast vary among women, ranging from 500 to 1,000 grams each; and 500 grams for a small-to-medium-sized breast and a large breast weighs over 750 to 1,000 grams. Breasts have 2 main tissues: glandular tissues and stromal tissues. The tissue composition ratio of the breast likewise widely varies among women. Therefore the fat-to-connective-tissue ratio determines the density of the breast. A mature human female's breast consists of fat, connective tissue and thousands of lobules - tiny glands which produce milk. Breast cancer normally starts off in the inner lining of milk ducts or the lobules that supply them with milk. The ductal system, or mammary tissue, is the critical part of the breast. Each breast has about six to eight milk ducts travelling from small bulbs called lobules within the surrounding fat of the breast and terminate at the nipple. When they are stimulated by the hormones secreted during pregnancy and birth, the lobules produce milk. The ductal system is completely lined with a layer of epithelial cells, where most breast cancers are thought to originate. During development and during periods of relative developmental quiescence, cell-to-cell interactions between epithelial cells, and stromal support cells, are very essential for maintenance of healthy tissue. Disruptions in these signaling paths may be critical early steps in the development of breast cancer. A malignant tumor can spread to other parts of the body.

The various imaging modalities present are magnetic resonance image (MRI), Ultrasound and mammograms, Microwave Imaging and Infrared Thermography that can be used to capture the breast image of a suspected person. The captured images are subjected to various kinds of noises. The main objective of preprocessing is to remove the irrelevant portions in an image and to enhance the image quality for further processes. Image segmentation is the method of partitioning the image based on different criteria. Breast cancer image segmentation from MRI images is done using an efficient automated scheme to provide an accurate image segmentation of the MRI images. This paper presents a review of the methods used in Preprocessing and efficient segmentation procedure. The review covers the noise reduction and image segmentation approaches.

II. LITERATURE REVIEW

A variety of algorithms have been proposed by various authors for Breast cancer segmentation. Various Denoising and image enhancement methods have been adopted for implementing this segmentation procedure.

M.Sucharitha *et al* has proposed an adaptive mean shift methodology in order to classify the brain voxels where the MRI image space is represented by a high-dimensional feature space called as space. The output of AMS consists of various modes. After pruning intensity based clustering techniques called k-means clustering algorithm is utilized to produce better results [4].

Albert Gubern-M´erida *et al* developed a method to automatically compute breast density in breast MRI. The framework is a combination of image processing techniques to automatically segment breast and fibro-glandular tissue. Intra- and interpatient signal intensity variation is initially corrected. The breast is segmented by detecting body-breast and air-breast surfaces. Subsequently, fibro-glandular tissue is segmented from the breast area using expectation–maximization [1].

R.Ramani *et al* In this paper the author has mentioned the various segmentation procedures like thresholding. Region growing, classifying, clustering, Artificial Neural Networks, Deformable models for MRI Breast image segmentation [6].

Prachi *et al* extracted an affected region from brain tumor MRI with the help of thresholding method of segmentation. Thresholding is one of the easiest ways of segmentation. It is based on different intensity values and colors [7].

Gopal, N.N.Karnan, *et al* Brain tumor detection helps in finding out the exact size and location of tumor. This paper proposes an efficient algorithm for brain tumor detection based on segmentation and morphological operations. Firstly quality of scanned image is enhanced and then morphological operations are performed to detect the tumor in the scanned image [8].

Ruchika Bansal, Darshan Singh Sidhu This paper focuses on clustering method such as Fuzzy C-means clustering algorithm that has been widely used for image segmentation. The algorithm was then combined with Active Contour method. Active Contours have been widely used as efficient image segmentation methods because they produce sub regions with continuous boundaries. The algorithms have been implemented and tested for various MRI images. The comparison is made with existing conventional Fuzzy C-means method [9].

ISBN : 978-93-86171-10-8

III. PROPOSED METHEDOLOGY

The proposed algorithm is to mainly separate the cancer portion from remaining healthy tissues and to evaluate the various performance metrics. The breast image with the cancer cells are shown below.

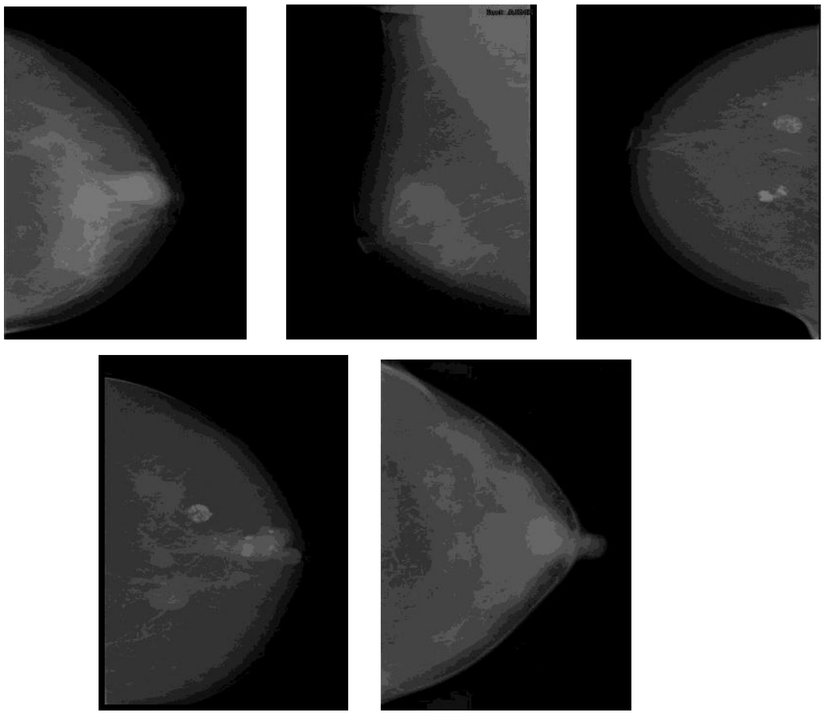


Figure 1 Breast MRI Images with cancer

The MRI image captured is mostly affected by noise. Hence preprocessing stage is required to suppress the unwanted noise and subsequently improve the image quality. The various stages are shown in Figure2.

1) Preprocessing
   a) Denoising
   b) Image enhancement
2) Segmentation

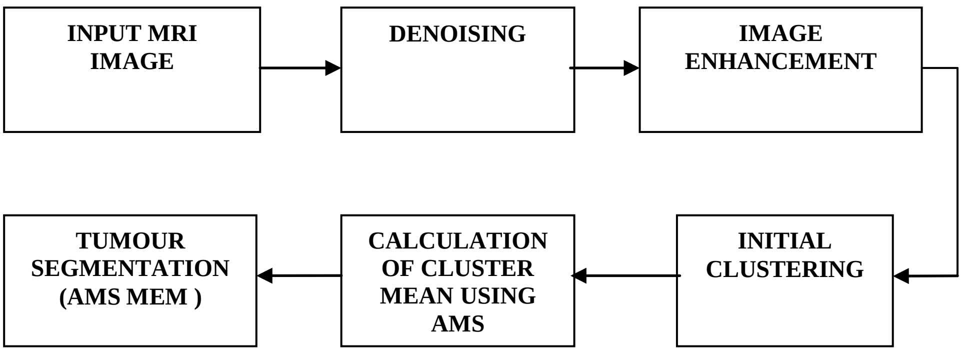


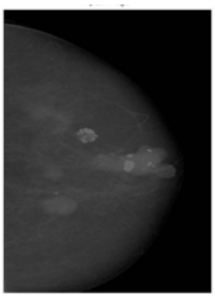
Figure 2 Block Diagram

1) Preprocessing

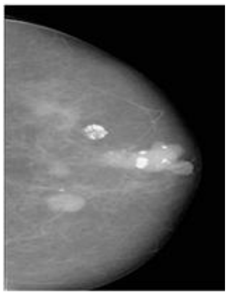
Image distortion is most crucial problems in image processing. Preprocessing involves noise removal and contrast enhancement of MRI image.

(a) Denoising

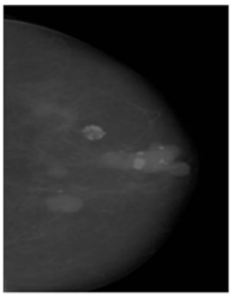
Image is distorted due to various types of noise such as Gaussian noise, Poisson noise, Speckle noise, Salt and Pepper noise and many more are fundamental noises[10]. These noises may be came from a noise sources present in capturing devices, faulty memory location or may be introduced due to inaccuracy in the image capturing devices like cameras, misaligned lenses, weak focal length, scattering etc. This results in the selection of suitable noise model for image Denoising [12].The various Denoising filters proposed in this paper for image noise removal are Median Filter, Adaptive Median Filter, Anisotropic, Diffusion Filter, Weiner Filter and Wavelet Filter. The image is filtered and various quality metrics are evaluated. Among all the filters anisotropic diffusion filter which is explained below showed better results.



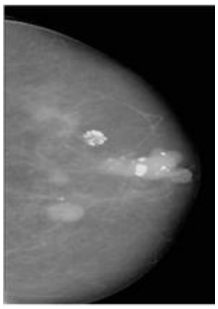
Input image



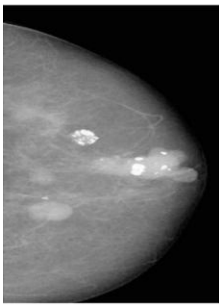
Adaptive Median Filter output



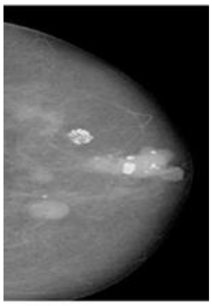
Anisotropic Diffusion filter output



Weiner Filter output



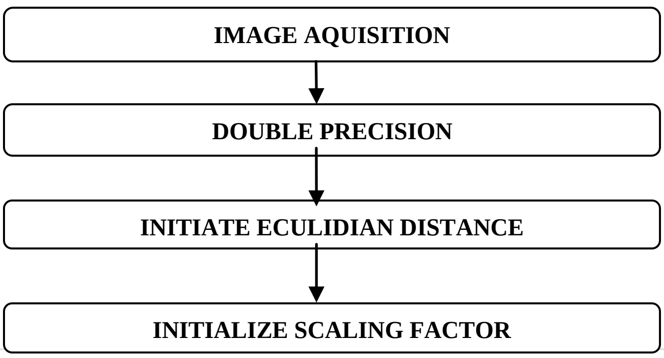
Median Filter output



Wavelet Filter output

Figure 3 Output of various filters

FLOW CHART- ANISOTROPIC DIFFUSION FILTER



↓

APPLY 2D CONVOLUTION MASK

↓

MULTI DIMENSIONAL FILTER USING 'IMFILTER'

↓

APPLY THE IMPULSE RESPONSE (DIFFUSION) COEFFICIENTS

↓

APPLY THE RECIPROCITY THEOREM ON THE FILTER IMAGE

↓

APPLY THE DIFFERENTIAL EQUATION USING PDE

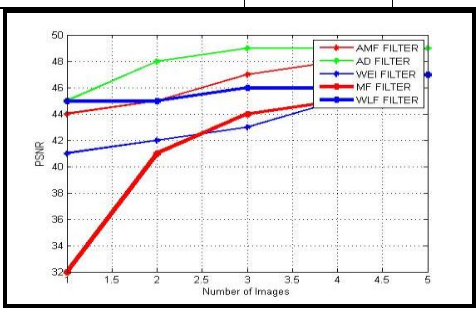
↓

OUTPUT DENOISED IMAGE

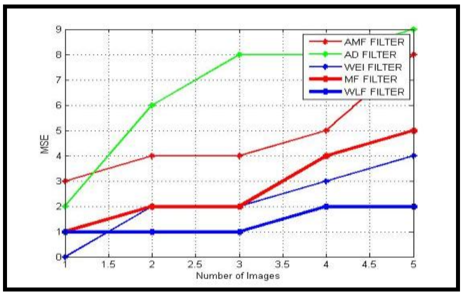
The following Table shows the comparison of various image quality metrics.

Table 1 Image quality metrics

FILTER (TECHNIQUE)	PSNR	MSE	AMBE	ENTROPY	SSIM
ADAPTIVE MEDIAN FILTER	48.78	8.593E-7	0.0102	4.6171	0.9892
ANISOTROPIC DIFFUSION FILTER	49.78	8.42E-6	0.2867	4.6676	0.9681
WEINER FILTER	45.89	1.672E-6	0.0031	0.1897	0.6639
MEDIAN FILTER	47.23	1.23E-6	0.0147	4.6193	0.9866
WAVELET FILTER	45.89	1.78E-6	1.36E-4	1.0819	0.9506



PSNR PLOT



MSE PLOT

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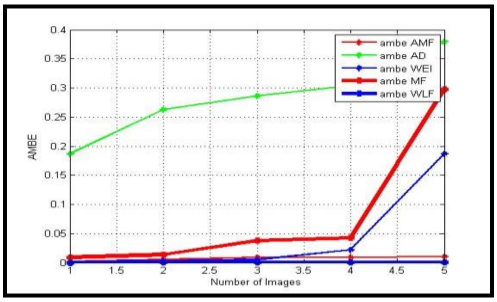
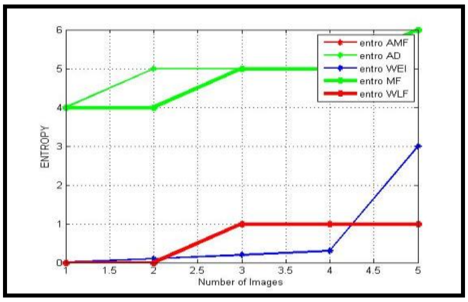
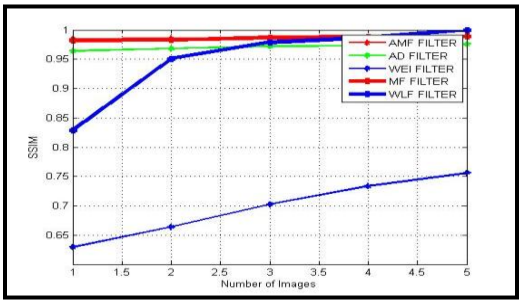
ISBN : 978-93-86171-10-8





AMBE PLOT **ENTROPY PLOT**

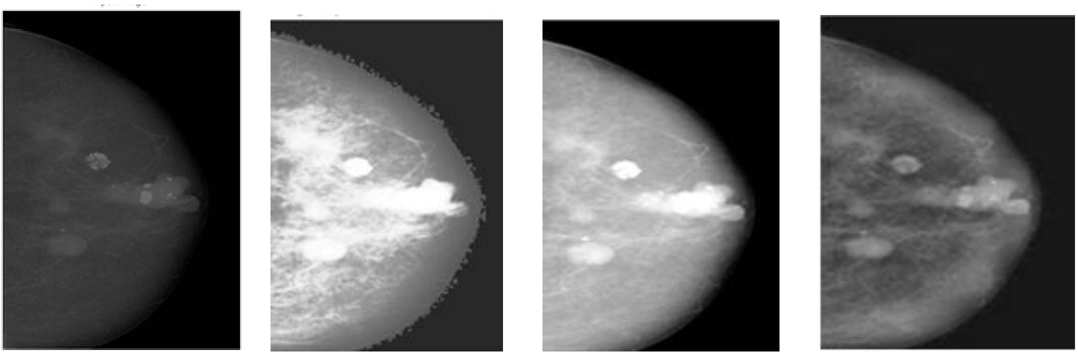


SSIM PLOT

Figure 4 Comparison of various filters (Image quality metrics) with 5 different MRI images

(a) Image Enhancement

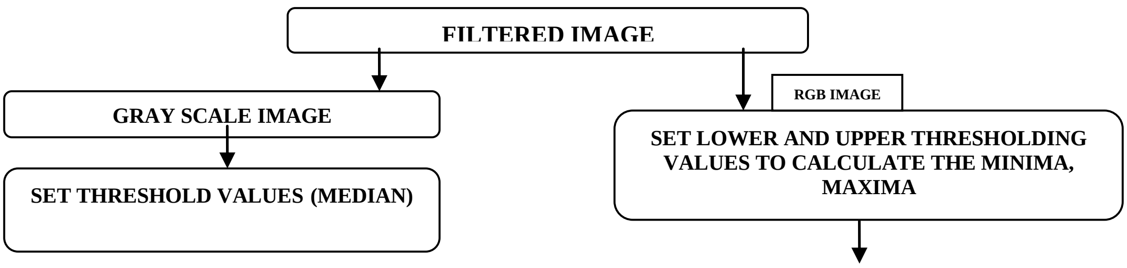
Image enhancement is the process of improving the quality of the image for human visual perception. This is done mainly to enhance the details present in an image for further processing. There are many methods used for image enhancement. Histogram Equalization is one of the most frequently used method [11].Mean adjustment method which is explained below showed better results.

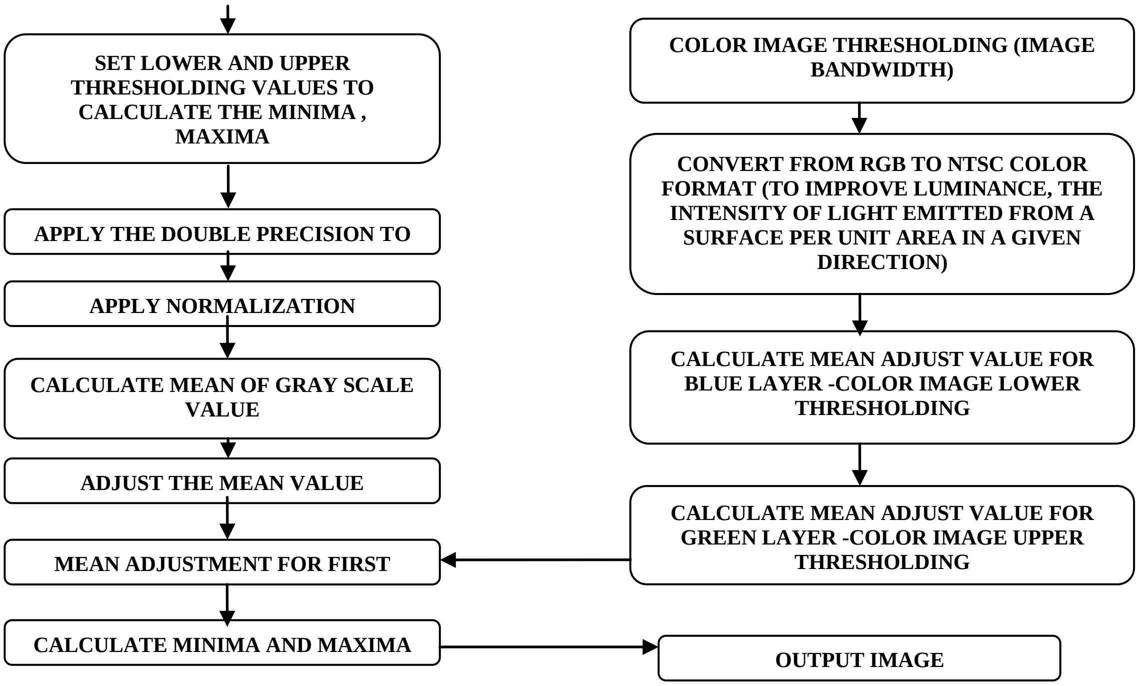


Input image Histogram Equalization Mean adjustment Contrast Limited Adaptive HE

Figure 5 Image Enhancement output

FLOW CHART – MEAN ADJUSTMENT

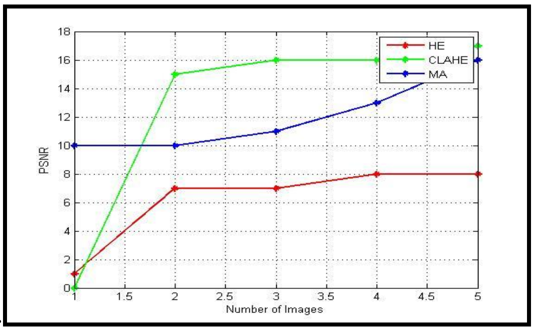




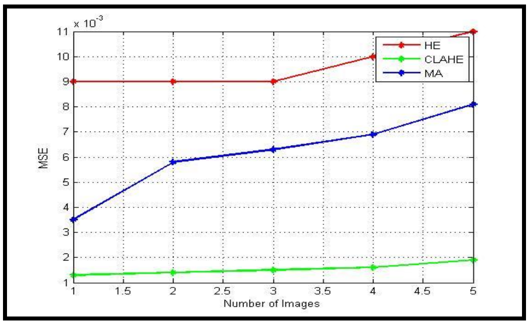
The following Table shows the comparison of various image quality metrics of image enhancement. Various image quality metrics are compared and tabulated

Table 2 Image quality metrics

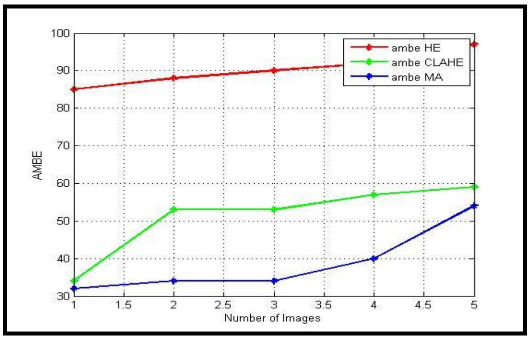
ENHANCEMENT TECHNIQUE	PSNR	MSE	AMBE	ENTROPY	SSIM
HISTOGRAM EQUALIZATION	7.7825	0.0108	92.457	4.1613	0.3022
CONTRAST LIMITED ADAPTIVE HISTOGRAM EQUALIZATION	16.3685	0.0015	34.9093	4.6282	0.5099
MEAN ADJUSTMENT	9.0660	0.0081	34.9093	5.5272	0.6562

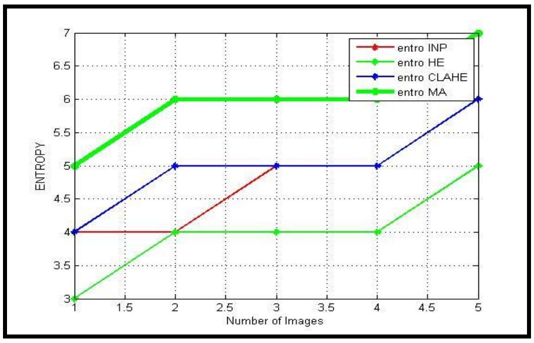


PSNR PLOT

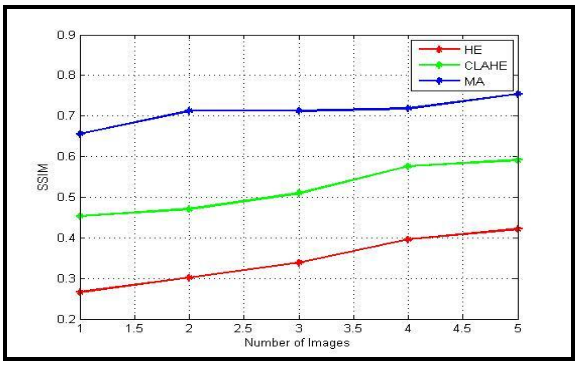


MSE PLOT





AMBE PLOT **ENTROPY PLOT**



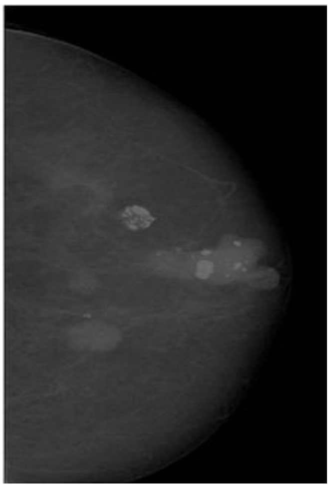
SSIM PLOT

Figure 6 Comparison of Enhancement methods (Image quality metrics) with 5 different MRI images

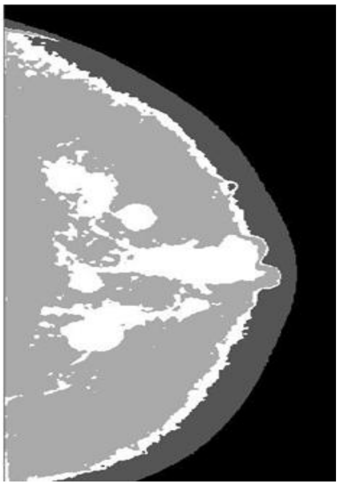
2) Segmentation

Image segmentation is the method of subdividing a digital image into multiple segments. The objective of segmentation is to simplify and change the image representation into something that is easier to analyze [3]. It is typically used to Locate tumors and other pathologies in images, Diagnosis, study of anatomical structure, Intra-surgery navigation etc. Image segmentation is the process of labeling every pixel in an image so that pixels with the same label share certain characteristics. There are numerous segmentation techniques used to segment the image. Segmentation can be done by Region Based Segmentation, Edge Based Segmentation, Threshold Segmentation, and Clustering Based Segmentation [14].

The different segmentation techniques used are Otsu's thresholding method, K-mean, region growing, region merging, histogram technique etc. Otsu's method measure of region homogeneity in terms of variance. It selects the threshold value by minimizing the within-class variance of the two groups of pixels separated by the thresholding value. Otsu's method is minimum error method. K-mean clustering is suitable for biomedical image segmentation, since the number of clusters for an image is known. The clustering is done by minimizing the Euclidean distance between centroid of cluster and data. In K-means clustering the number of clusters is known. Region based segmentation is a technique based on the similarities in the given image [5]. The method proposed in this paper is Adaptive Mean Shift Modified Expectation Maximization (AMS MEM) Algorithm.



Input image



Clustered image

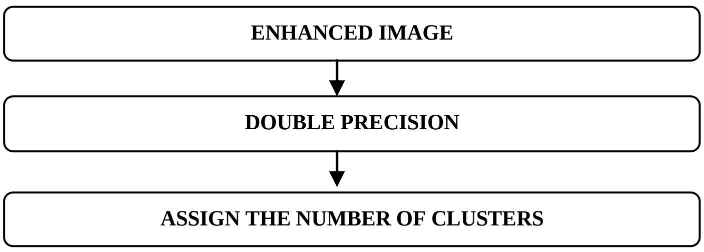
Segmented image

Figure 7 Adaptive Mean Shift Modified Expectation Maximization segmentation

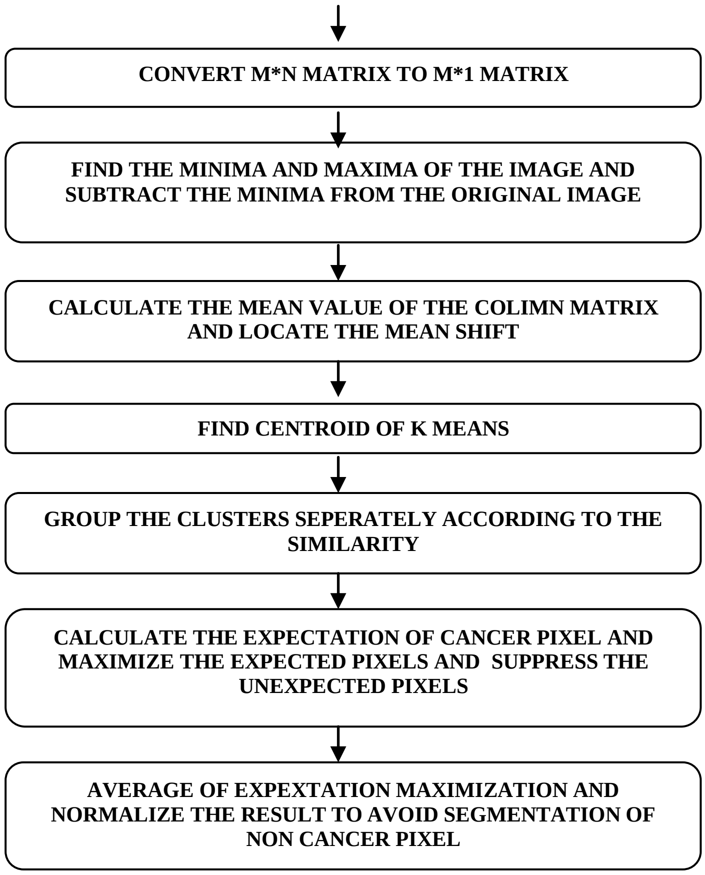
In the proposed method, we first perform image region segmentation by using the AMS algorithm, and we then treat those regions as nodes along the image plane and apply a graph structure to represent them. The final step is to apply the MEM method to partition these regions. The AMS algorithm is a robust feature-space analysis approach [6] which can be applied to discontinuity preserving smoothing and image segmentation problems.

The algorithm starts by assigning the number of cluster. After converting the image into m*1 format the mean value of the image is calculate so as to find the location of the column image. The centroid is calculated using k-means algorithm. Further the expectation of cancer pixel is calculated and those pixels are maximized simultaneously by suppressing the unexpected pixels. The resultant is then normalized to avoid non cancer pixels to be segmented and finally the cancerous portion is segmented leaving behind the non-cancerous portion. The following flowchart explains the segmentation method.

FLOW CHART – AMS MEM



ISBN : 978-93-86171-10-8



The following Table shows the comparison of performance metrics of various images

Table 3 Performance metrics

FEATURES	IMAGE 1	IMAGE 2	IMAGE 3	IMAGE 4	IMAGE 5
MEAN	23.2952	80.8804	50.4178	62.9503	0.1731
STD	73.4686	118.6715	101.5609	86.6927	109.9529
MEDIAN	0	0	0	0	0
VARIANCE	2.947e7	4.238e7	4.743e7	2.146e7	3.921e7
COVARIANCE	1.1022e3	2.1633e3	1.811e3	1.044e3	1.883e3
MINIMA	0	0	0	0	0
MAXIMA	255	255	255	255	255
MODE	0	0	0	0	0

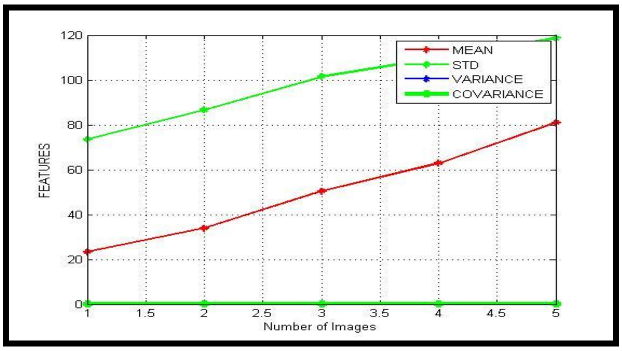


Figure 8 Comparison of first order features for 5 input MRI images

Advantage of Proposed algorithm is that it has good for convergence of gradients of the image pixels. It is the fastest algorithm when compared to the k means algorithm and k Means algorithm. The Mean shift AMS MEM algorithm can have linear convergence and the speed is based on how many information is lost .Mean shift AMS MEM algorithm is applicable for RGB color space images. The exact segmentation of the tumor of MRI is possible

III. CONCLUSION

The main drawback of the standard EM for image segmentation is that the objective function does not take into account of the spatial information in the image, but deal with images as the same as separate points. Therefore, as mentioned in many literatures the standard EM algorithm is sensitive to noise and a noisy pixel is always wrongly classified because of its abnormal feature. In this paper, we proposed a new AMS MEM that incorporates the spatial information into membership function in order to improve the segmentation results. In the new spatial function we used two contribution factors. The first one was according to distances between central pixels with neighbor pixels. The second factor was calculated according to value difference of central pixel with neighbor pixels. Using of these contribution factors caused that spatial function is made of according to distance and value pixels. The new method was tested on MRI images and evaluated by using various cluster validation functions. Preliminary results showed that the effect of noise in segmentation was considerably reduced with the new algorithm than with the EM.

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