CHEST X-RAY ENHANCEMENT FOR THE PROPER EXTRACTION OF SUSPICIOUS LUNG NODULE

MANOJ R. TARAMBALE
Electrical Department
Research Scholar PACIFIC University, Udaipur
MM College of Engineering, Pune
email: manoj_tarambale@ yahoo.com

NITIN S. LINGAYAT
Electrical Department
DR. Babasaheb Ambedkar Technological University's Institute of Petrochemical Engineering, Lonere, India
email:nslingayat@yahoo.com

ABSTRACT
CAD (Computer Aided Diagnosis) system can detect lung cancer only when the quality of the image is excellent. Certain enhancement techniques are employed to improve the quality of X-ray image. By using enhancement technique, CAD systems will able to detect even a small lung nodule from the noisy blurred X-ray images. Average mean filter and Median filter is used to remove noise (Gaussian and salt & pepper noise) from the image. Contrast stretching, histogram equalization,negativity, log transform and power law transform are used to improve the intensity and contrast related problem.High boost filtering is used for sharpening the details in the image. For segmentation, modified thresholding algorithm and morphological operation are used. In the present study, images from the JSRT database and the images which are collected from nearby local hospitals are used to test the performance of the algorithm.

KEYWORDS- Contrast Stretching; cancer; Histogram Equalization; Thresholding; Malignant; Benign; Morphological.

I. INTRODUCTION

Computer-Aided diagnosis (CAD) using image processing technique has become one of the major research subjects in medical imaging and diagnostic radiology. In any CAD system, extraction of important features from the bio-medical image is only possible when the details of the image are clearly visible and the segmentation is done properly and accurately.

In any image processing based CAD system, Image enhancement is the first and the most important step. In image enhancement, the pixels of the image are manipulate in such a way that it improve the interpretability or perception of information contain in the image for human viewers and to provide a desirable input for CAD system [1]-[2].

Lung nodule is a mass of tissue located in the lungs. It can be malignant or benign. Benign nodules are not cancerous. This means it is localized and has not spread to other parts of the body or invaded and destroyed nearby tissue but malignant are cancerous. They spread to other parts of the body and destroyed nearby tissue. Therefore, for early detection of cancer, it is necessary to analyze the lung nodule. Detection of the lung nodule from the X-ray image is very difficult task. Detection is difficult not only because of the small size of the nodule but also because of the presence of the various types of noise which are generally introduced in the image due to the environmental factors and human errors.

Presence of dust particle or moisture on the X-ray machine lens, presence of hair on the body of the patients and several other factors introduce salt and pepper noise in the X-ray image. Wrong setting of X-ray machine, relatively very low or very high contrast in the image, circuit noise, high temperature etc. affects the quality of the image. While analyzing such image, radiologists face a difficulty in identifying the location of lung nodule. Sometime overlapping of some body organ or ribcage bone also produce problem in detecting lung nodule.

The paper is organized as follows - Section II describes the filtering techniques. Section III describes the enhancement technique. Segmentation techniques like modified threshold technique and morphological operation are describe in section IV.Various stages of the proposed algorithm are given in section V. Results obtained are presented in section VI.

II. FILTER

The principle source of the noise in an image arises during image acquisition and during the processing of the image in the CAD system. No matter how much care one takes, some amount of noise always creeps in the image.

a) Arithmetic mean filter:- it computes the average value of the corrupted image $g(s,t)$ in the area defined byS_{xy}. The value of the restored image $\hat{f}$ at point (x,y) is simply the arithmetic mean computed using the pixels in the region defined by S_{xy}.

$$\hat{f}(x,y) = \frac{1}{mn}\sum_{(s,t)\in S_{xy}} g(s,t) \quad (1)$$

S_{xy}represent the set of coordinates in a rectangular sub image window of size $m \times n$ centered at point (x,y). Mean filter smooth's local variations in an image and noise is reduced as a result of blurring. Figure1 represent the arithmetic mean filter mask.

1/9

1	1	1
1	1	1
1	1	1

Fig.1 3×3 Arithmetic mean filter mask

*b)*Median Filter - Median filter is an order statistic filter. It replaces the value of a pixel by the median of the intensity levels in the neighbourhood of that pixel.

$$\hat{f}(x,y) = \underset{(s,t)\in S_{xy}}{median}\{g(s,t)\} \quad (2)$$

The value of the pixel at (x,y) is included in the computation of the median. For random noise, median filter provide excellent noise reduction capabilities, with considerably less blurring than linear smoothing filters of similar size. Median filters are particularly effective in the presence of both bipolar and unipolar impulse noise. Figure.2 shows a 3×3 mask of median filter. Size of maskmay vary according to the application requirement.

1	1	1
1	1	1
1	1	1

Fig.23×3 Median filter mask

The steps to perform median filtering are as follows-

1) Assume a 3×3 or 5×5 or 7×7 empty mask.
2) Place the empty mask at the left hand corner of the image.
3) Arrange the pixels in ascending or descending order.
4) Choose the median from this ordered pixel.
5) Place the median at the centre.
6) Move the mask in a similar fashion from left to right and top to bottom.

c) High Boost Filtering: - It eliminates the low frequency regions while retaining or enhancing the high frequency component. It is also used to sharpen blurred images. Unlike other high pass filter it retains the background of the image [5]. High boost filter is a modified version of the high pass filter. In high boost filter, some of the background is passed along with high frequency content. In high pass filter

Resultant image = original image – low pass image (3)

To pass some of the background, original image f (m, n) is multiplied with multiplicative factor 'A', this gives high boost filtering, hence.

High boost $= A \times f(m, n) - \text{low pass}$ (4)
Adding and subtracting 1 with gain factor
High boost $= (A - 1) \times f(m,n) + f(m,n) - \text{low pass}$ (5)
But $f(m,n) - \text{low pass} = \text{high pass}$
From above
High boost $= (A - 1) \times f(m,n) + \text{high pass}$ (6)
If $A = 1$ then
High boost $= \text{high pass}$ (7)
If $A > 1$ then some of the original signal is added back to the high pass result. This process restores background into the high passed image. A standard 5×5 high boost filter mask is shown in Fig.3.

-1	-1	-1	-1	-1
-1	-1	-1	-1	-1
-1	-1	X	-1	-1
-1	-1	-1	-1	-1
-1	-1	-1	-1	-1

Fig.3 5×5 Mask for high boost filter

In Fig.3, $X = 25A - 1$ ('A' can have any value and A >0).

III. ENHANCEMENT

a) Negativity, log and Power law transformation – Negative simply means inverting the gray level i.e. if pixel in original image is black, then it will look white and vice versa.the transformation is given by
$s = (L - 1) - r \quad (r_{max} = L - 1)$ (8)

Hence when
$r = 0, s = L - 1$ and when $r = L - 1, s = 0$.

Where $(L - 1)$ is a maximum gray value in the image.

Log transformation maps a narrow range of intensity values in the input into a wider range of output levels. The opposite is true of higher values of input levels. Transformation is used to expand the values of dark pixels in an image while compressing the higher level values. The opposite is true for inverse log transformation.

$$s = c \log(1 + r) \quad (9)$$

where c is a constant.

Power law transformations have the basic form

$$g(x,y) = c \times f(x,y)^{\gamma} \quad (10)$$

c and γ are positive constant.Non-linearity's encountered during the image capturing and displaying can be corrected by adjusting the value of gamma.

Figure 4 shows the transformation diagram for negativity, log transform and power law transform.

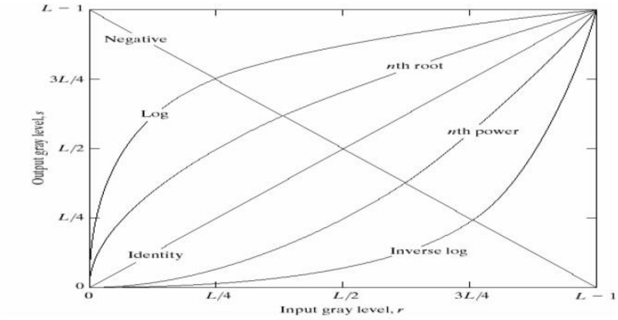

Fig.4 Negative, logand power law transformation. vertical axis represent output grey level 's' and horizontal axis represent input grey level 'r'.

b) Histogram and Histogram Equalization – The histogram of an image is a plot of the number of occurrences of gray levels in the image against the gray-level values. The histogram provides a convenient summary of the intensities in an image. The horizontal axis of the graph represents the tonal variations, while the vertical axis represents the number of pixels in that particular tone. The left side of the horizontal axis represents the black and dark areas, the middle represents medium grey and the right hand side represents light and pure white areas. The vertical axis represents the size of the area that is captured in each one of these zones.

Histogram equalization is a process that attempts to spread out the gray levels in the image so that they are evenly distributed across their range. It reassigns the brightness values of pixels based on the image histogram. Histogram equalization provides more visually pleasing results across a wider range of images [4], [9].

c) Contrast Stretching – Many times images are of low contrast due to poor illumination or due to wrong setting of the lens aperture. In this method, contrast of the images is increase by making the dark portions darker and the bright portions brighter [3].

The basic transformation is shown in the Fig. 4. In the Fig. 5, the horizontal axis r represents the input pixel value, and the vertical axis's' represents the output pixel value. As seen, there are three straight line segments used to transform an input pixel to its resulting output pixel value. The transformation from the input pixel value to the output pixel value is via the piecewise linear profile shown in the Figure 5.The parameters specifying the contrast stretch mapping are the four values r2, s2, r3, s3, which determine the position of the intermediate straight line segment. Modifying any of these four values modifies the contrast stretch transformation. The values of r1, s1, r4, s4 are fixed.

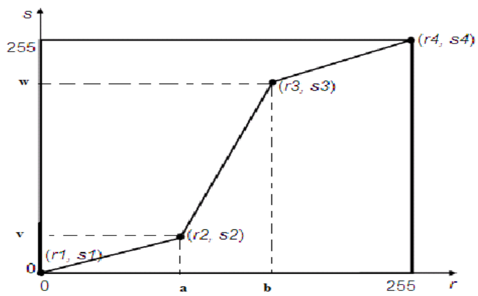

Fig. 5 Modified gray level for contrast stretching

Formula for contrast stretching algorithm is given by

$$S=\begin{cases} \mathbf{l.r} & \mathbf{0} \le \mathbf{r} < a \\ \mathbf{m.(r-a)+v} & \mathbf{a} \le \mathbf{r} \le \mathbf{b} \\ \mathbf{n.(r-b)+w} & \mathbf{b} \le \mathbf{r} < L-1 \end{cases} \quad (11)$$

NOVATEUR PUBLICATIONS
INTERNATIONAL JOURNAL OF INNOVATIONS IN ENGINEERING RESEARCH AND TECHNOLOGY [IJIERT]
ISSN: 2394-3696
VOLUME 3, ISSUE 11, Nov.-2016

IV. SEGMENTATION

In computer vision, segmentation is the process of partitioning a digital image into multiple segments (sets of pixels, also known as super pixels). Image segmentation is typically used to locate objects and boundaries (lines, curves, etc) in images. More precisely, image segmentation is the process of assigning a label to every pixel in an image such that pixels with the same label share certain visual characteristics.

a) Thresholding – Extreme Contrast Stretching yields thresholding. The Contrast Stretching Diagram in Fig. 4, it is noticedthat, if the first and the last slope are made zero and the centre slope is increased, thenit will lead to a threshold transformation i.e. if r1=r2, s1= 0 and s2 = L-1, is a thresholding function [12], [15].

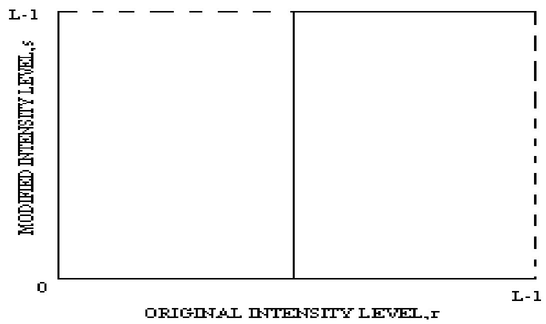

Fig.6Thresholding

The formula for achieving thresholding is as follows

$s = 0;$ if $r \leq a$ (12)

$s = L - 1;$ if $r > a$ (13)

The thresholding algorithm can be modified and the modified thresholding transformation in shown in Fig.7. In normal thresholding, only one threshold value is used but in the present studies, two threshold values are used. By this method, the segmentation of the selected/interested pixels can be done. Remaining pixel are assign the value zero. Segmented pixel will contain the same pixel value as they were having in the original image. Formula for modified thresholding technique is as follows

$s = 0;$ if $r < a$ and $b > r$ (14)

$s = r;$ if $a \geq r$ and $r \leq b$ (15)

Where ‘ r’ is a original image gray level and ‘L’ is max gray level in the image , ‘a’ and ‘b’ are the two threshold.

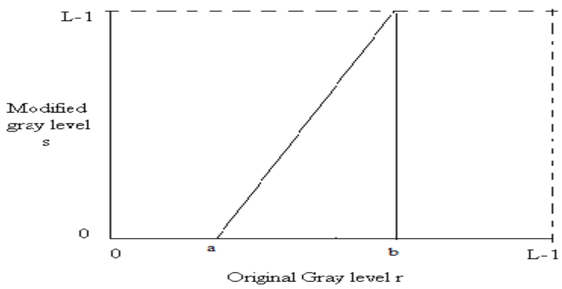

Fig.7 Modified thresholding

b) Morphological operation: - it is a science of form or structure. it is used as a tools for extracting image components that are useful in representing regions and shapes.

1) Dilation: - it adds pixels to the boundaries of objects in an image. The number of pixels added depends on the size and shape of the structuring element. It has effects of filling in the valleys between spiky edges.

2) Erosion: - it reduces the number of pixels from the object boundary. The number of pixels removed

depends on the size of the structuring element. It has effect of deleting spiky edges.

3) Opening: - morphological opening of an image is basically erosion followed by dilation, using the same structuring elements. It smoothes the contours of the image, break down narrow bridges and eliminate thin protrusions. Opening operation isolates objects which may be just touching one another.

4) Closing: - morphological closing of an image is basically dilation followed by erosion, using the same structuring elements. It tends to fuse narrow breaks and eliminates small holes. This simplifies the process of assessing the separation of particles.

IV. BLOCK DIAGRAM

Figure 8 indicates various steps used in algorithm for enhancing the X-ray image are explain on the basis of following block diagram

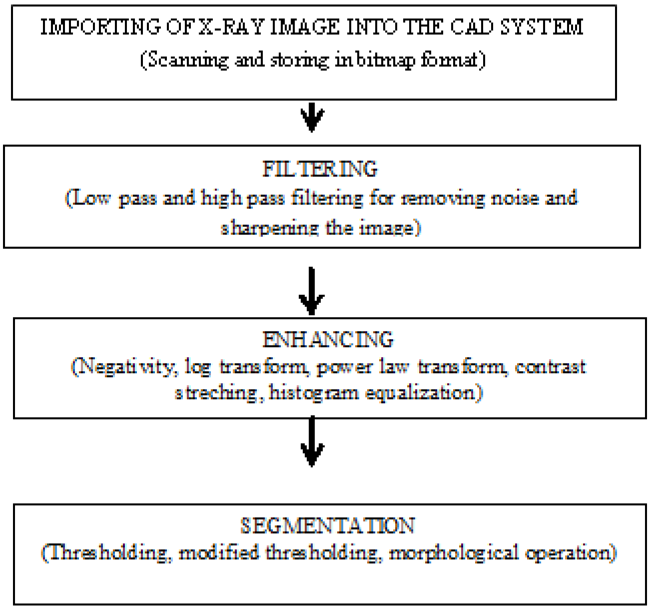

Fig. 8 Stages of proposed algorithm

V. RESULT AND DISCUSSION

JSRT database and local hospitals had provided X-ray images for the research purpose. These images are scanned by using a high resolution scanner and stored into the Bitmap format in hard drive. All the scanned images are resized to 800 × 1200 (8-bit). It is converted into the negative image.

Some bit of noise is introduce during the scanning process is removed by using low pass filter. Low pass filter remove noise by blurring the image. In order to sharpen the image high boost filter is used. Contrast, brightness and illumination problem is solved by using log transform, power law transform, histogram equalization and contrast stretching.

Thresholding and modified thresholding is used to extract suspicious region from the image. Some time suspicious area is difficult to extract from the remaining regions. In such cases morphological operations are used.

The method and procedure, which are presented in this paper are relatively easy to implement and easy to used. As these techniques are the basic technique in the field of digital image processing. Digital image processing toolbox in MATLAB, simplifies the implementation of algorithm. Segmented images obtain in the last can be used further for feature extraction and classification purpose. Above steps are explained with images Fig.9 (a)-9(n).

ISSN: 2394-3696
VOLUME 3, ISSUE 11, Nov.-2016


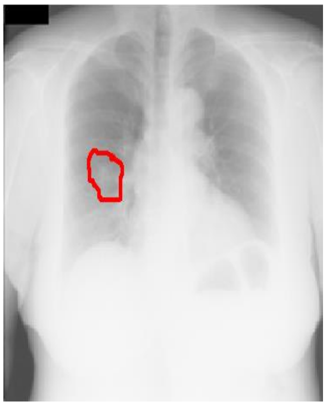

Fig.9(a) Original imageFig.9(b) location of lung nodule Marked with red circle

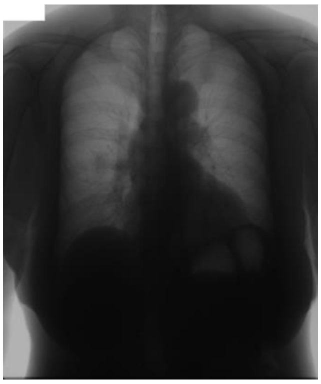
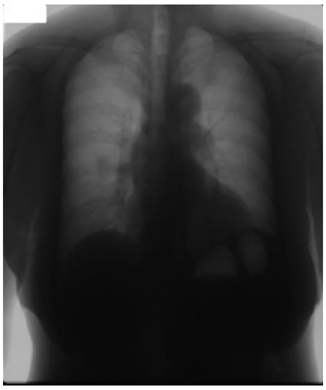

Fig.9(c) Negative imageFig.9 (d) Median filter (5×5)

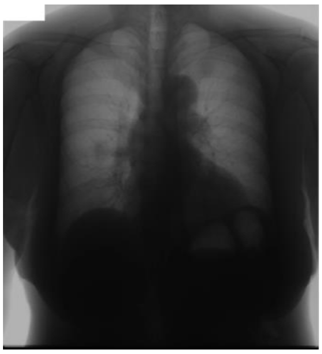


Fig.9 (e) Mean Filtering (5×5)   Fig.10 (f) High Boost filtering

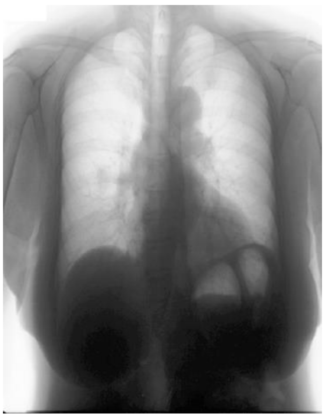
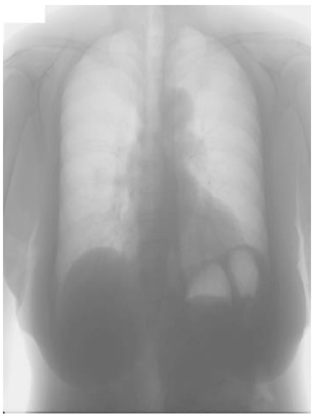

Fig.9 (g) Histogram Equalized Image   Fig.9(h) log transform

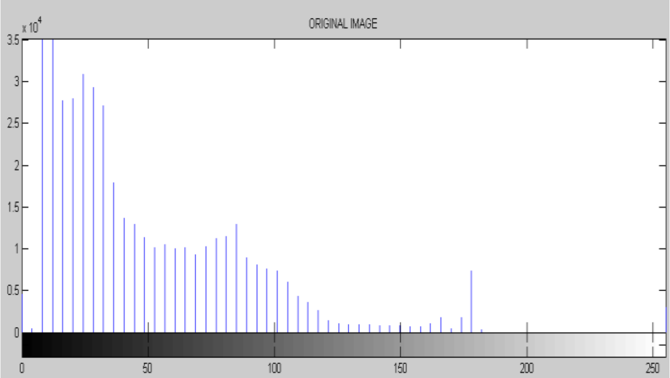

Fig.9 (i) Histogram (original image)

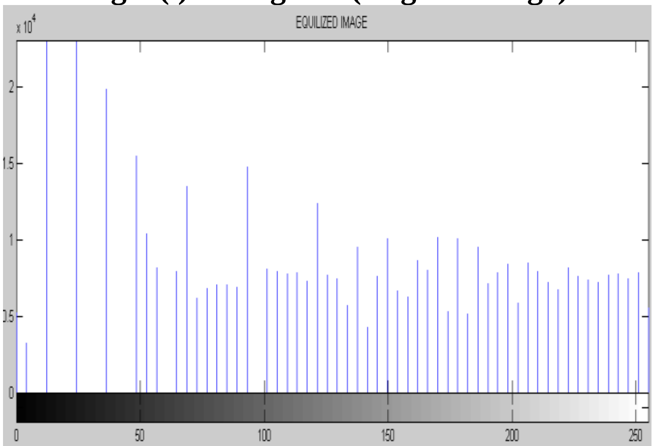

Fig.9 (j) Histogram (equalized image)

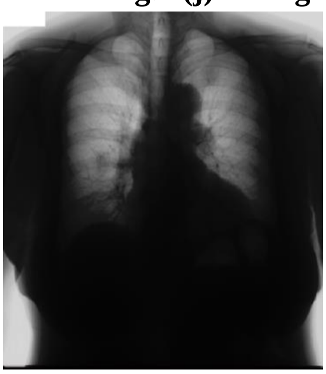
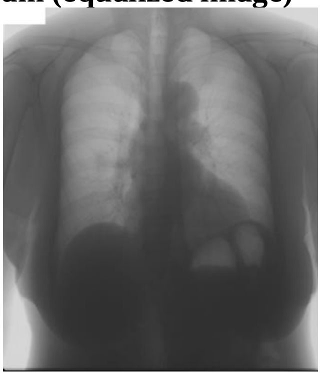

Fig.9 (k) Contrast Stretching Fig.9 (l) Power law transform


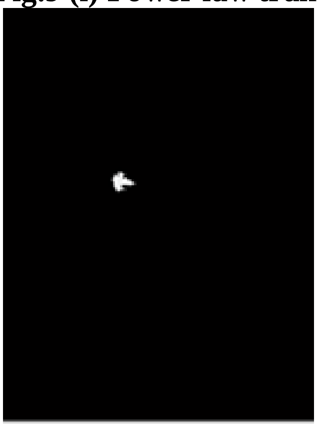

Fig.9 (m)modified thresholding Fig.9 (n) Segmented lung nodule

CONCLUSION

This paper presents an enhancement technique which is relatively simpler to implement with any application software. These techniques reduce the irrelevant information, which makes segmentation process easier and more accurate. Low pass filtering is required after every processing step as some noise always creeps into the image. By using contrast stretching, image contrast is adjusted in such a way that the interested area is clearly seen. Difficulty of separating lung nodule from the rest of the region is solved by using modified thresholding. Thresholding with two threshold values help successfully in segmenting lung nodule. Morphological operation is used with modified thresholding for extracting suspicious area from the original image.

REFERENCES

1) Rafael C. Gonzalez, and Richard E. Woods, "Digital Image Processing",. 3rdedition, Prentice Hall, 2008.
2) Rafael C. Gonzalez, and Richard E. Woods, "Digital Image Processing using MATLAB",. 2nd edition, Prentice Hall, 2009.
3) A.K. Jain, "Fundamental of Digital Image Processing," Prentice Hall, Englewood Cliffs, NJ.1989
4) J.Damodhar, Dr.D.Sathyanarayana, "Implementation of contrast streching algorithm on lung effected images for analysis" International Journal of Advances In Electronics Engineering, pp 267-272, 2010
5) Haidi Ibrahim and Nicholas Sia Pik Kong, "Brightness preserving dynamic histogram equilization for image contrast enhancement" , IEEE Trans. Consumer Electronics ,vol.53, no.4,Nov 2007.
6) Kenny Kal Vin Toh and Nor Ashidi Mat Isa "Locally adaptive bilateral clustering for image deblurring and sharpness enhancement", IEEE, pp 1227-1235, Sep 2011.
7) K.A.G. Udeshani, R.G.N. Meegama & T.G.I. Fernando, "Statistical feature-based neural network approach for the detection of lung cancer in chest x-ray images" International Journal of Image Processing (IJIP), vol, (5),issue (4) , 2011.
8) Joung-Youn Kim, Lee-Sup Kim, and Seung-Ho Hwang, "An advanced contrast enhancement using partially overlapped sub-block histogram equalization", IEEE Transactions On Circuits And Systems For Video Technology, vol. 11, no. 4, APRIL 2001.
9) Fabrizio Russo "An image enhancement technique combiningsharpening and noise reduction", IEEE Transactions on Instrumentation and Measurement, VOL. 51, NO. 4, AUGUST 2002.
10) Govind N Sarage , Dr. Sagar Jambhorkar , "Enhancement of mammography images for breast cancer detection using histogram processing techniques" , IJCST , vol. 2, issue 4, Oct - Dec. 2011
11) S Jayaraman, S Esakkirajan and T Veerakumar "Digital Image Processing" 3rd edition, Tata McGraw Hill, 2009.
12) Andrea Polesel, Giovanni Ramponi, and V. John Mathews, "Image enhancement via adaptive unsharp masking", IEEE Transactions on Image Processing, vol. 9, no. 3 March 2000.
13) Salem Saleh AL-Amri, N.V. Kalyankar and Khamitkar S.D, "Image segmentation by using threshold technique", JOURNAL OF COMPUTING, vol. 2, issue 5, May 2010.
14) Ping-Sung Liao, Tse-Sheng Chen and Pau-Choo Chung, "A fast algorithm for multilevel thresholding", Journal of Information Science and Engineering, vol. 17, pp. 713- 727, 2001.
15) Beant Kaur, Mr.Anil Garg, "Comparative study of different edge detection techniques", International Journal of Engineering Science and Technology (IJEST), Vol. 3 No. 3 March 2011.
16) Orlando J. Tobias, Rui Seara , "Image segmentation by histogram thresholding using fuzzy sets" , IEEE Transactions On Image Processing, vol. 11, no. 12, DECEMBER 2002.
17) Mamta Juneja , Parvinder Singh Sandhu, "Performance evaluation of edge detection techniques for images in spatial domain" , International Journal Of Computer Theory And Engineering, vol. 1, no. 5, December, 2009.