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QUALITY ENHANCEMENT OF CHEST X-RAY IMAGE FOR ACCURATE EXTRACTION OF LUNG TUMOUR AND IT'S ANALYSIS

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ABSTRACT

The accuracy or ability of CAD (Computer Aided Diagnosis) system in bio-medical engineering to detect lung cancer mainly depends upon the quality of the image and the accuracy of features extracted. This paper presents an enhancement technique by which a CAD system will able to detect even a small lung nodule from the noisy blurred X-ray images. Paper analyses effect of various types of the filters used to remove noise from the image. Contrast stretching, histogram equalization, high boost filtering, negativity are used to remove the illumination problem and for sharpening the details in the image. For segmentation, modified thresholding algorithm and edge detection are used to segment the suspicious lesion / tumour from the rest of the X-ray image. For better understanding of the tumour portion M-profile maps are drawn using MATLAB software. In the present study, images from the JSRT database and the images those are collected from nearby local hospitals are used to test the performance of the algorithm developed. The points stated above are very helpful in the process of lung cancer detection using image processing tool from simple chest X-ray radiography image.

Keywords: Noise filter, Contrast Stretching, Histogram Equalization, Thresholding, Malignant, Benign, M-profile plot.

I. INTRODUCTION

The ultimate aim of any CAD system is to extract maximum important features from the bio-medical image. 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. Image enhancement is the first and the most important step of any image processing algorithm. 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. Bad illumination while taking 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. To overcome the above problem, a CAD system is developed using GUI toolbox and digital image processing toolbox in MATLAB.

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The paper is organized as follows – first part describes pre-processing via filtering techniques, negativity, contrast stretching and histogram equalization. Second part describes the segmentation technique like modified threshold technique and edge detection. Various stages of the proposed algorithm are given in next part. In the last paper presents Results and Discussions, Conclusion and acknowledgement.

II.   FILTERING

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. Noises which are commonly found in any image are Gaussian noise and salt and pepper noise. This noise can be easily removed by using low pass filter. In the present study, median filter is used to remove the noise [4][5].

a) Median Filter - Median filter has numerous advantages over the other low pass filters. Other low pass filters remove the noise by blurring it till it is no longer seen. But in the process they blur the edges. Therefore making the task of segmentation difficult. In order to eliminate salt and pepper noise non-linear filter known as median filter is. Median filter not only eliminate salt and pepper noise but also preserve the sharpness of the image edges [8].

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.

b) 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 filtering is a modified version of the high pass filter. In high boost filtering, some of the background is passed along with high frequency content, in high pass filter [10] [12].
        Resultant image = original – low pass

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 $= A \times f(m, n)$ – low pass
Adding and subtracting 1 with gain factor
High boost $= (A-1) \times f(m, n) + f(m, n)$ – low pass
But $f(m, n)$-low pass=high pass
From above
High boost $= (A-1) \times f(m, n)$ +high pass
If A = 1 then
High boost = high pass
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.
Here,   X = 9A – 1 (We can select any value of A).

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

Fig.1 Mask for high boost filter

c) Negativity: Negative simply means inverting the gray level i.e. like in the original image will now look white and vice versa. The digital negative image can be obtained by using a simple transformation given by [1]

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s = 255 – r   (r_{max}=255)
Hence when
r = 0, s = 255 and when r = 255, s = 0.
In general
s = (L - 1) – r

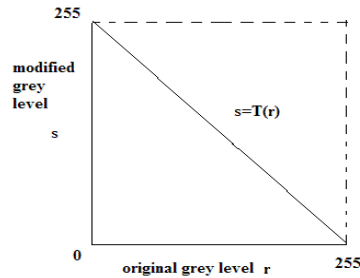Where L is a maximum gray value in the image

Fig. 2. Negative transform for an 8 bit image

d) 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, but it is unable to convey any information regarding spatial relationships between pixels. 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. Thus, the histogram for a very dark image will have the majority of its data points on the left side and center of the graph. Conversely, the histogram for a very bright image with few dark areas and/or shadows will have most of its data points on the right side and center of the graph [11].

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].

e) 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, we are increasing the contrast of the images by making the dark portions darker and the bright portions brighter [3].

The basic transformation is shown in the Fig. 3. In the Fig. 3, 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. Stated otherwise, the transformation from the input pixel value to the output pixel value is via the piecewise linear profile shown in the Fig. 3.

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.
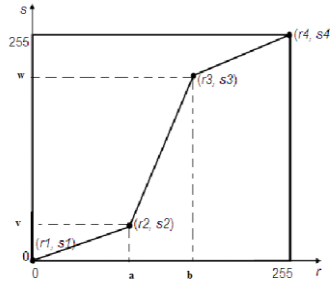
Fig. 3. Modified gray level for contrast stretching

Formula for contrast stretching algorithm is given by

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

III. SEGMENTATION

In computer vision, segmentation is the process of partitioning a digital image into multiple segments (sets of pixels, also known as super pixels). The ultimate goal of segmentation is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze. 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. In our, study we are doing segmentation by using modified threshold technique and by edge detection.

a) Thresholding: Extreme Contrast Stretching yields thresholding. If we observe the Contrast Stretching Diagram in fig. 3, it is noticed that, if the first and the last slope are made zero and the centre slope is increased, then we will get a threshold transformation i.e. if *r1 = r2, s1 = 0 and* s2 = L - 1, we get a thresholding function [12], [15]. It is shown in fig 4 [16].

The formula for achieving thresholding is as follows
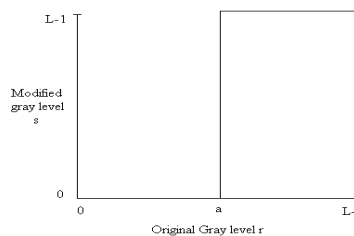
S=0;   if r ≤ a
S=L-1;   if r > a

Fig. 4. Thresholding

In this way we have modified the thresholding algorithm. In normal thresholding, we had only one threshold value but in our study we had used two threshold value. By this method, we are doing the segmentation of the selected/interseted pixels. Remaining pixel are assin the value zero. Segmented pixel will contain the same pixel value as they were having in the original image [13] [14]. Formula for modified thresholding technique is as follows

S = 0 ;   if r < a and b > r
S = r ;   if a ≥ r and r ≤ b

Where ' r' is a original image gray level and 'L' is max gray level in the image , 'a' and 'b' are the two threshold.
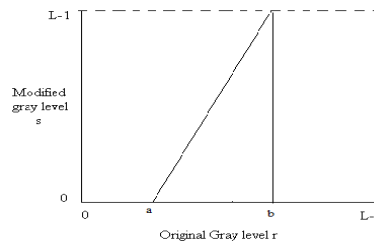
*Fig. 4. Modified thresholdin***g**

b)   **Edge detection:**Edge detection is a fundamental tool in image processing, machine vision and computer vision, particularly in the areas of feature detection and feature extraction, which aim at identifying points in a digital image at which the image brightness changes sharply or more formally, has discontinuities [15]. The purpose of detecting sharp changes in image brightness is to capture important events and changes in properties of the image. It can be shown that under rather general assumptions for an image formation model, discontinuities in image brightness are likely to correspond:

- discontinuities in depth
- discontinuities in surface orientation
- changes in material properties
- Variations in scene illumination

Applying an edge detection algorithm to an image may significantly reduce the amount of data to be processed and may therefore filter out information that may be regarded as less relevant, while preserving the important structural properties of an image. If the edge detection step is successful, the subsequent task of interpreting the information contents in the original image may therefore be substantially simplified. In our study we had used a Sobel mask with compass operator [18].

c)   **Sobel operator:** Sobel mask is given by [1]
d)

Fig. 5(a) F$_x$ *Fig. 5(b) Fy*

Fig. 5(a) and Fig. 5(b) are Sobel masks. These masks will detect horizontal and vertical edges. Sobel operator is easy to implement. By using this mask edges are detected in horizontal as well as vertical direction, in Sobel operator [10].

$$\nabla F \approx | (Z_7+2Z_8+Z_9) - (Z_1+2Z_2+Z_3)|$$
$$+ | (Z_3 + 2Z_6+Z_9) - (Z_1+2Z_4+Z_7)|$$

With the use of compass operator, we can similarly find the edges in all the possible direction. Compass masks are generated by simply rotating the Sobel's mask in all directions. It also detects weak edges.

-1	0	1
-2	0	2
-1	0	1

Fig. 6(a)

1	0	-1
2	0	-2
1	0	-1

Fig. 6(b)

0	-1	-2
1	0	-1
2	1	0

Fig. 6(c)

-1	-2	-1
0	0	0
1	2	1

Fig. 6(d)

-2	-1	0
-1	0	1
0	1	2

Fig. 6(e)

0	1	2
-1	0	1
-2	-1	0

Fig. 6(f)

Above masks are known as compass operator, which is generated using Sobel's mask. Figure 6(a) - 6(f) are the mask which will detect edges in all possible direction.

e) Block diagram / Algorithm [17]


```
Scanning of x-ray image
        ↓
Store in bmp format (800×1200)
        ↓
Negativity of the image
        ↓
Low pass filtering-median (5×5)
        ↓
High boost filtering and histogram
equalization
        ↓
Low pass filtering –median (3×3)
        ↓
Contrast stretching
        ↓
Thresholding
        ↓
Edge detection
```
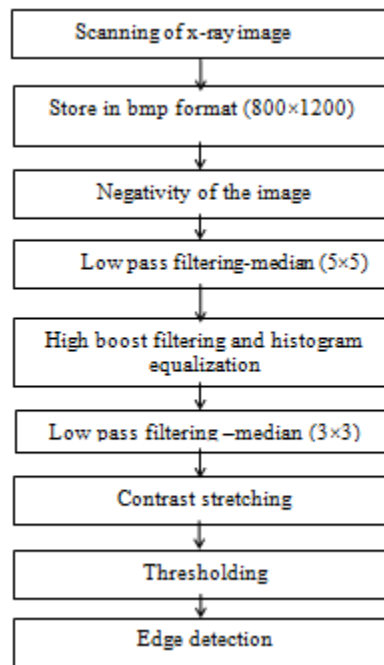
Fig. 7 Stages of proposed algorith

f)   **M-profile Plots:**Theseplotsare plotted using MATLAB special function. If we scratch line on the segmented region then, we will get all pixel variations along the line. This can be plotted in 2D and 3D matter. We can analyze color graphs also for better analysis.

IV.   RESULT AND DISCUSSION

In our study we have used x-ray images from the public JSRT database and images collected from local hospitals. These images are scanned by using a high resolution scanner and stored into the storing device. These scanned images are digitally stored in bitmap format and all thescanned images are resized to 800×1200 (8-bit). All the enhancement techniques are tested on the x-ray image one by one. In figure 8(a) – (b), it is clearly seen that the detection of nodule location is difficult to detect because of high brightness. To overcome this difficulty we have covered the original image into negative image Fig (c). Visibility of this image is improved to certain level.Median filter is used to remove the Gaussian and salt & pepper noise .Median filter not only reduce the noise but it also introduce blurring in the image. To remove this blurring, we had used a high boost filter. Unlike other high pass filter it preserve the background of the image as well as it also sharpen the blurred edges Fig (d)-(e).

Histogram equalization provides a perfect image with uniform brightness Fig (f). It modifies the intensity levels and makes them almost equal. All gray levels are equally distributed to entire image and clearly visible. It is not only providing clear image but also helps to modify the intensity levels for future analysis. Equalization makes the contrast to increase at the most populated range of brightness values of the histogram Fig (g)-(h).

Some bit of noise is also introduced during the high boost filtering and histogram equalization. To remove the noise median filter is again used but with small mask.
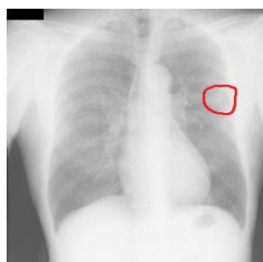
Contrast stretching is used to enhance particular range of pixels. In our study, we have used contrast stretching to enhance those pixels which are showing lung nodule. It also used to increase the dynamic range of gray level in the image being processed Fig (j).After following this process image is now ready for segmentation. Thresholding with two thresholds are used to extract particular range of pixel from the image. By using this technique lung nodule is easily and accurately extracted from the x-ray image. Edge detection is used to detect the edges of the lung nodule Fig (k). We have used a Sobel operator with compass operator to detect edges in all possible direction Fig (l).

Output of M-profile plot and mesh plot helps to understand pixel variation in the suspicious region and color mesh graph indicates tissue density variation in the tumour region.

The method and procedure, we have used for the enhancing the image are the basic enhancement technique in digital image processing. Thus the implementation with any software is less complex.Segmented images can be used for feature extraction and classification.

Fig.8 (a) Original image   *Fig. 8(b) location of lung nodule*
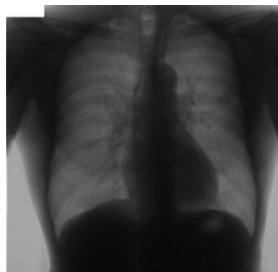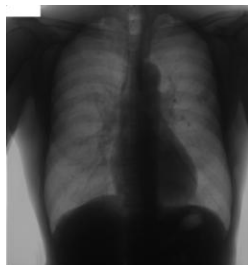*Marked with red circle*

Fig. 8(c) Negative image   *Fig. 8(d) Median filter (5×5)*

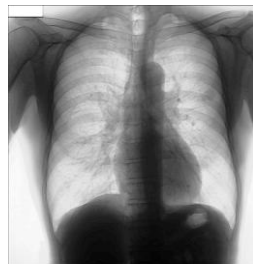*Fig. 8(e) High Boost filtering*   *Fig 8 (f) Histogram Equalized image*
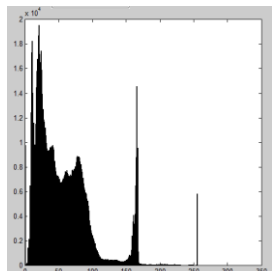

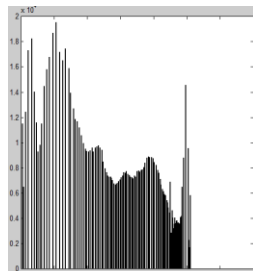*Fig. 8(g) Histogram (original image)*   *Fig. 8(h) Histogram (equalized image)*
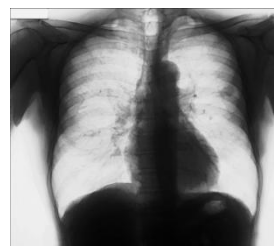

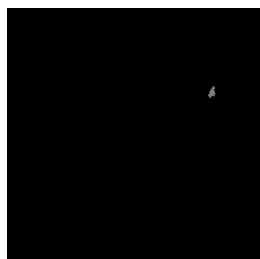*Fig. 8 (i) Median Filtering (3×3)*   *Fig. 8 (j) Contrast Stretching*

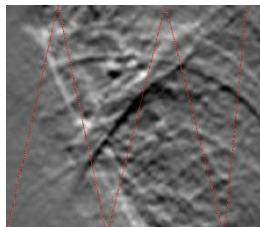*Fig. 8 (k) Segmented lung Nodule*   *Fig.8 (l) Edge detection*
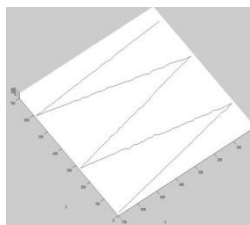
Fig 8(m) Lines on the Tumour
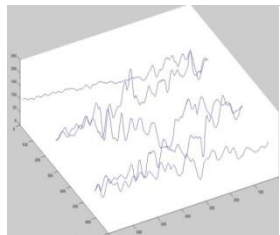

Fig 8(n) Lines X-Y plane
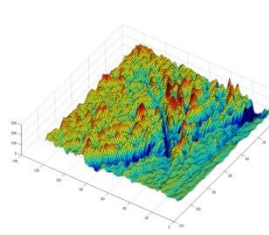

Fig 8(o) 3D Profile Plot

Fig 8 (p) Mesh Plot

V.   CONCLUSION

This paper presents a relatively simple procedure for extracting a lung nodule from the x-ray image. Low pass filtering is required after every processing step. If the value for the contrast stretching is accurate then the lung nodule can be seen clearly seen in the image. Thresholding with two threshold values help successfully in segmenting lung nodule. For detection of all the edges in the image, edge detection should be done in all direction. M-profile plot and Mesh plot plotted in MATLAB helps to understand texture and pixel variation in the suspicious region of the tumour. Algorithm developed works satisfactorily to segment the tumour from the rest of the image.

VI.   ACKNOWLEDGEMENT

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