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X-Ray Lung Image Enhancement by Spatial Filtering

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Abstract : The problem with lung radiological imaging techniques such as CT, HRCT, MRI and X-Ray is that, it is not that easy for the Physicians to detect most of the major diseases related with the lungs just by visualizing image, although in some cases it is possible, but till that time diseases has reached the next stage. The problem with images is that at a time, they may be blurred, out of focus, improperly bright and noisy, which makes the examination more difficult. One more problem is the pixel intensity level, which is same for the tissues. One of the solutions to all above problems can be image Enhancement, although it does not give us the assurance of high quality outcomes. Image Enhancement methods are broadly categorized into spatial and frequency domain [9]. Spatial domain is our subject of concerned.

Key words: Lung X-ray image, Spatial filtering, smoothing, sharpening

I. INTRODCUTION

Image Enhancement technique is an application specific that is it may be suitable for one problem but might be inadequate for another [1]. Medical imaging uses enhancement techniques for reducing noise, smoothing, contrast stretching, edge enhancement and sharpening details by mean of filtering in order to increase their clarity.

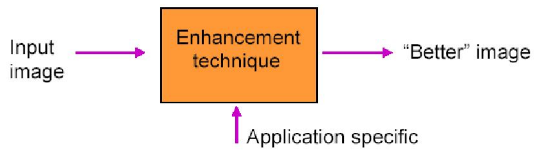

Fig1. Enhancement Technique

Since subtle details of image plays a crucial role in diagnosis and treatment of diseases. The effectiveness can be evaluated by comparing before and after results. In this paper lung images of X-ray, Computer Tomography, High Resolution Computer Tomography, MRI and PET can be taken for the analysis by mean of spatial filtering. But in this paper, results are calculated on X-ray image of lungs. The filtering results will help us to decide, which process suits for that particular image. The image size considered is256*256. All the algorithms of filtering are carried out in MATLAB 2009b.The RME and PSNR [5] parameters are calculated for every algorithm. Images are tested with salt and pepper noise. Our aim is to enhance the image, remove noise, at same time taking care of not losing the details and important information, which will decide presence or absence of diseases. Image enhancement with proper medical diagnosis together will be a result oriented process.

Image enhancement can also work with values of image pixels in the neighbourhood and corresponding values of sub image. The sub image is called as filter. The values in filter sub images are called as coefficients.

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Fig.2.Normal X-ray of lungs

Image enhancement techniques are broadly divided into two types. First is spatial filtering, which directly operates on the image pixel and second is frequency domain which operates on the frequency transform of an image [2]. In this paper, we are considering spatial filtering for analysis on X-ray of lung image.

II. SPATIAL FILTERING

Spatial filtering is the effective way for enhancement. It is defined as a neighbourhood and its operation is performed on the pixels inside the neighbourhood. Typically the neighbourhood is much smaller than that of f(x, y) and its size is rectangular [7]. A filtered image is generated as the centre of the mask which moves to every pixel in the input image. It is based on the equation g(x, y) =T [f(x, y)], where T operates on neighbourhood of pixels. There are two types of spatial filtering one is linear and the other is nonlinear. It is linear, when output is weighted sum of input pixels, whereas the method that does not satisfy this property are non linear. For linear spatial filter the response is given by sum of products of filter coefficients and corresponding image pixels spanned by filter [8].

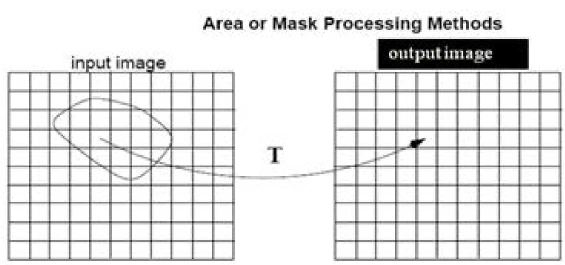

Fig3.Spatial Filtering

Various filters for spatial filtering are

a) Smoothing filters
   i) Mean filter (averaging)
   ii) Gaussian filter
   iii) Median filter
b) Sharpening filter
   i) Laplacian filter
   ii) High Boost filtering
   ii) Derivative filter

With this, the performance measurement of normal and enhanced images will be done with MSE (mean square error) and PSNR (power to signal noise ratio) to display the comparisons.

A) Smoothing filter

This filter reduces noise and eliminates small details of image. The elements of the mask must be positive and sum of mask must be one after normalization. Two types of smoothing filters are linear smoothing and non linear smoothing filters. A linear

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filter is implemented using weighted sum of pixels in successive window, whereas non weighted sum of pixels are non linear filter. They are spatially invariant. Linear smoothing filters removes high frequency components, due to which sharp details of an image is lost [3]. The smoothing filters are

i) Averaging filter

It is simple non linear filter also known as mean filter. In averaging filter, the mask size determines the degree of smoothing and loss of details. Noise which varies randomly above and below a normal brightness value can be reduced by averaging neighbourhood of values. It is given by an equation

$$h[i,j] = \frac{1}{M} \sum_{(k,l)\in N} f[k,l] \tag{1}$$

Where, M is the total number of pixels in the neighbourhood N. now if we want to design 3* 3 averaging filter, then we can use the equation

$$h[i,j] = \frac{1}{9} \sum_{k=i-1}^{i+1} \sum_{l=j-1}^{j+1} f[k,l]. \tag{2}$$

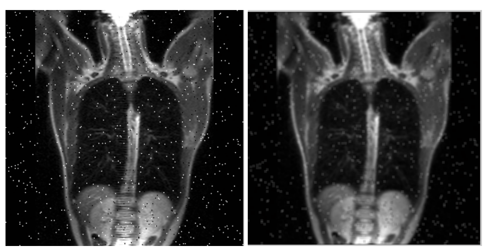

Fig.2 (a).Salt and pepper noise (b) Average filters (3*3) on image with salt and pepper noise

Fig2 (a) shows lung image affected by salt and pepper noise, whereas (b) shows the application of average filter.

ii) Gaussian filter

Gaussian smoothing is low-pass filtering, which suppresses high-frequency details which includes noise and also edges, while preserving the low-frequency components of the image, which don't vary too much. In other words, the filter blurs everything that is smaller than the feature of image. This means they are linear filter. The weights are samples of Gaussian function and it is given by the equation

$$G_\sigma(x,y) = \frac{1}{2\pi\sigma^2} \exp^{-\frac{x^2+y^2}{2\sigma^2}} \tag{3}$$

The mask size is the function of σ. It controls the amount of smoothing, as σ increases more samples must be obtained to represent the Gaussian function accurately.Figure3 Shows the application of Gaussian filter on the Gaussian noise affected image.

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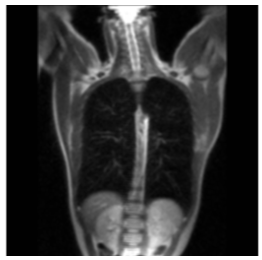

Fig3.Gaussian filter of size 3*3, sigma=03

iii) Median filter

Averaging filter gives better estimation of the image, when the average is taken over homogeneous neighbourhood with zero mean noise. But with increase in noise mean, blurring of boundaries take place. The main problem of averaging filter is that it blurs discontinuities in intensity values, so an alternative approach is median filter. It is a non linear filter and is very effective for removing salt and pepper noise at the same time most other small artefacts that replace few ideal image values with noise values of any kind. The method first sort the pixels in ascending order and then select the value of the middle pixel as the new value of pixel[i, j].

Fig.4 Median filter (3*3) on the noisy image

Let A [i], where i ranges from 0 to n-1 be sorted array of n real numbers. The median in the set of numbers in A is A [(n-1)/2]. Median filter can smooth noisy regions yet preserve the structure of boundaries between them. Fig4 shows median filter effect on noisy image giving better result compared to average filter.

b). Sharpening filter

It highlights fine details of the image, which has been blurred. The elements of the mask contain both positive and negative weights. Sum of the masks weight is equal to zero after normalization [12]. Filters used for sharpening the images are

i) Laplacian filters

This filter is an example of second order derivative of enhancement. Unfortunately image features with noise get enhanced by Laplacian operator. Hence image should be smooth before applying Laplace operator.

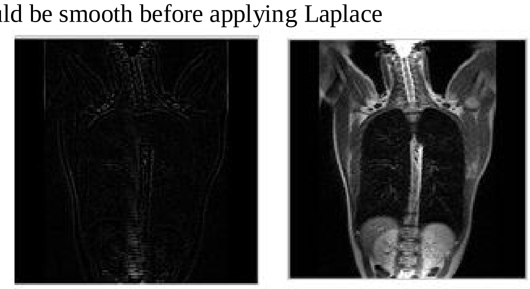

Fig.5 (a) Laplacian filtered (b) Sharpened lung image

The sharpening of lung image is done by using Laplacian equation (2^{nd} derivative) given as

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$$g(x,y)=f(x,y)+c\left[\Delta^2 f(x,y)\right] \quad (4)$$

Where f(x, y) is the input image, g(x, y) is the sharpened image and c=-1 for filter mask. Figure 5(a) is the result of equation (1) which produces greyish edge line and other areas are made dark (background). Now this filtered image is combined with original image as the result background is preserved and sharpened edge is obtained [4] which can be seen in figure 5(b).

ii) High Boost Filtering

High boost filtering emphasizes the edges but details that are low frequency components may be lost. It is composed by an all pass filter and an edge detection filter (Laplacian filter), which emphasizes edges and makes image sharper. It amplifies input image and then subtract a low pass image from it to get high boost [11].

High Boost = (A-1) original image+ High pass.

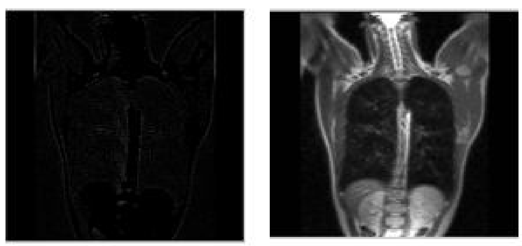

Fig.6 (a) (b) Results of High boost filtering

We get high pass filter for A=1 but, If A>1, then part of original image is added back to high pass filtered image. Hence it is unsharp masking filter, which removes blurred parts and enhances the edges.

iii) Derivative filter

Taking derivative of an image, results in sharpening of image. The derivative of an image can be computed using gradient [13].

$$grad(f)=\begin{pmatrix}\frac{\partial f}{\partial x}\\ \frac{\partial f}{\partial y}\end{pmatrix} \quad (5)$$

A gradient [10] is a vector which has both magnitude and direction. Magnitude provides information about edge strength. It is perpendicular to the direction of the edge. Edge is where the changes occur. This change is measured by derivative, that is first derivative has maximum magnitude or second derivative is zero for biggest change [6]. Derivative is high everywhere and smoothing of the image is must before applying. Figure 7 Shows, the result of first derivative on lungs with different sigma values.

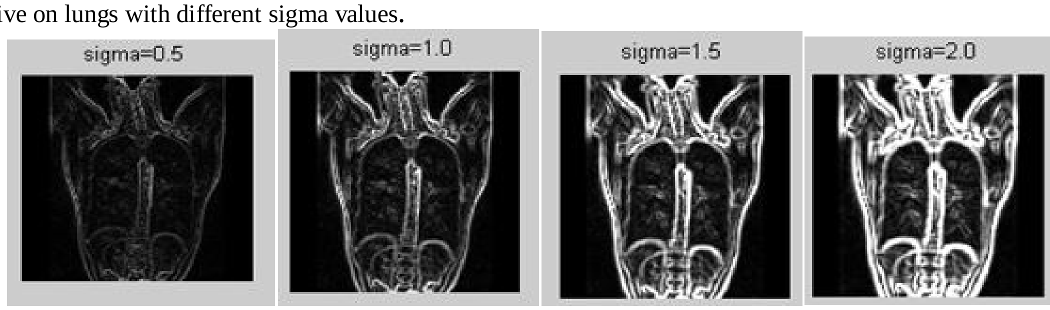

Fig.7 Results of first derivative with sigma=0.5, 1, 1.5 & 2.0

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III. RESULTS

Various filters for smoothing and sharpening are applied on the X-ray of the lung images in a MATLAB. The performance parameters used are MSE and PSNR for the analysis of unfiltered and filtered lung X-ray image. The MSE is mean squared error that's helps to check the similarities between two images. It is the average of square of error. Small value of MSE means small error of function used. PSNR is the ratio of maximum signal power to noise power. High PSNR indicates about better reconstruction, which can be observed from experimental result of Table1. .

Table 1.Eperimental result of various filters under spatial filtering

Filter	RMSE	PSNR
Averaging filter	70.8197	11.16
Gaussian filter	43.8971	31.74
Median filter	24.0427	20.54
Laplacian filter	79.6320	10.14
Derivative filter	61.886	12.33
High Boosting filter	70.5224	11.19

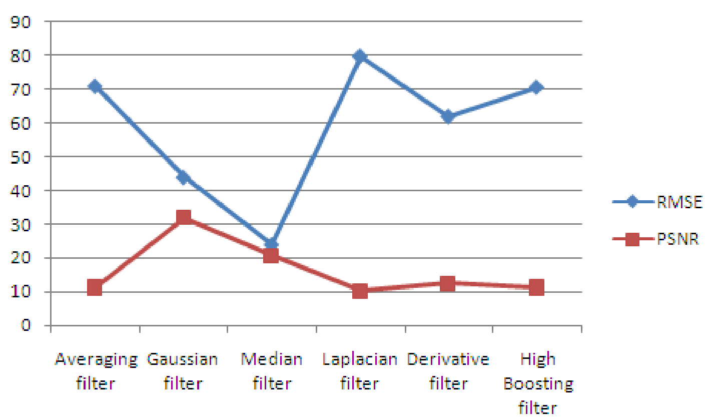

Fig.8 RMSE and PSNR values for various filters through graph

IV.CONCLUSION

The main aim of this paper is to highlight the effect of spatial filtering on radiological X-ray image of lungs. So that decision can be taken for applying the proper spatial filtering method to enhance the image. This paper shows. how the visual representation of an image is improved. Besides this, we tried to calculate MSE and PSNR values to get the parameter performance for before and after result images. Filtering method is going to vary for the same image of different pixel intensities. Hence according to the application, image enhancement technique should be used.

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BIOGRAPHY

Prof. Kale Vaishnaw G is recently working as Assistant Professor in Dr.Vikhe Patil Engineering College, Ahmednagar (MS), India. He has 10 years of teaching experience in the department of E&TC. He has completed M.E. in Electronics from Government college of Engineering, Aurangabad. His field of interest is Image processing and Signal Processing. Research area includes Biomedical Engineering.