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Preprocessing by Contrast Enhancement Techniques for Medical Images

S.Perumal[1] and T.Velmurugan[2]

[1]*Research scholar, Department of Computer Science, Vels Institute of Science, Technology and Advanced Studies (VISTAS), Chennai, India.*

[2]*Associate Professor, PG and Research Department of Computer Science, D.G.Vaishanav College, Chennai, India.*

[1]*s_perumal70@rediffmail.com*

[2]*velmurugan_dgvc@yahoo.co.in*

Abstract**—**Image processing is a technique of improving the quality of an image after removing irrelevant image data from image in various applications and domains. Medical images contain lot of irrelevant and unwanted parts in its actual format of the scanned images. To remove such annoying parts in an image, it is required some of the image preprocessing techniques in order for better visualization of the images before finding the diseases in particular. The core objective of this research work is to preprocess the Lung images and enhance the quality of the images using preprocessing techniques. Enhancement of the image quality is obtained by implementing filtering technique, removal of noise and contrast enhancement methods. The process of enhancing pixel intensity and image quality are also carried out after preprocessing. After the preprocessing, the image quality is increased.

Keywords**—***Image Enhancement; Gaussian noise Removal; Speckle noise Removal; Wiener Filter; Median Filter; Gaussian Filter;*

I. INTRODUCTION

The collected raw images have to be cleaned before analyzing process. Noises present in the images have to be removed and unclear objects have to be enhanced. The well known image processing technique named pre-processing was implemented for enhancing the quality of the image. The raw MRI consists of irrelevant items which reduces the overall accuracy.

Two dimensional images are represented with digital image containing finite set of picture elements commonly known to be pixels. Digital image processing makes storage of image data, data transmission and representation in human understandable manner [1]. The usage of digital image processing is widely spread in the field of many medical diagnostics applications such as.

i) Image enhancement/restoration

ii) Medical image visualization

iii) Artistic effects

iv) Industrial inspection

v) Law enforcement.

Imaging technology in Medicine made the experts to view the inner human anatomical organs for easy diagnosis. It also helps to make keyhole surgeries for reaching the interior parts, without opening too much of the body. Abnormal growth of cells which affects normal cells in living being is considered as cancer diseases.

In this research work, Magnetic Resonance images (MRI) are taken for the detection of Lung cancer as the initial method for identifying diseases by physicians with more accuracy level. MRI images are difficult to interpret. Therefore these images are processed in a way that can further used for segmentation which enables the doctors to identify Micro calcification or Mass in the lung for further diagnosis. Preprocessing includes removal of unwanted or irrelevant areas and to make prominent by increasing the contrast [2].

An image resolution enhancement and preprocessing technique for cleaning or removing noise was proposed. Removing noise affected parts from image without damaging the edges of the images are final part of preprocessing.

This research paper is organized as follows. Section 2 discusses about Review of Literature, Section 3 explains clearly about materials and methods used for this research work. Section 4 shows Experimental results carried throughout the preprocessing process. Finally, section 5 concludes the research work with its findings.

II. REVIEW OF LITERATURE

Universally Lung cancer is the leading cause of cancer deaths, among human being. The major cause of lung cancer is due to smoking and various other factors.

The menace of lung cancer increases with interval of time and number of cigarette a person smokes. If a person quit smoking after many years, the person has a possibility to reduce significantly from developing lung cancer [3]. American cancer Society's estimates 228,190 new cases of lung cancer about and deaths due to lung cancer about 159,480 in the United States for the year 2013. It also predicts that 1.3 million people are affected with this disease every year and getting treated and 1.3 million people death due to this disease [1]. Early detection of lung cancer improves the survival and manage rate.

Identifying lung cancer in early stage is most difficult part for doctors. Nearly 81 percentage of lung cancer are identified at the middle or advance stage only [2].

In order to detect it at its early stages, regular screening is very important which can reduce the number of deaths due to lung cancer. Lung cancer patients might not have any symptoms at initial stages but it can lead to death if not detected and treated on time [6].

Thoracic radiology uses Magnetic Resonance images (MRI) as one of the popular medical image technique [16]. Many research work deals with CT-Scan images for detecting tumors and lung cancer [4], [27].

However, very few research works was carried out to classify tumor based on the outcome images. Early cancer identification is made only based on patient clinical data.

Identifying cancer effected parts from the lung and curing cancer has been a major medical research carried over many decades [5]. Nowadays, digital image processing techniques are incorporated in many medicinal areas. They turn out to be well established as practical, versatile, strong computational methodologies with solid theoretic support and with strong potential to be effective in any discipline, especially in healthcare.

Over the last two decades, a much amount of research work has been conducted for automatic cancer identification. Implementation of Gabor filter algorithmic technique by Mokhled S. Altsrswneh used as a major part for enhancing a better image. The researcher also uses auto enhancement Fast Fourier Transform (FFT) algorithm for segmentation by using threshold approach and marker control watershed segment approach, which shows the uniqueness by using different techniques from various other researchers. The proposed FFT technique also improves the quality of an image and accuracy based on Gaussian rules. Necessary features are extracted by using techniques like pixel comparison and mask labeling [18]. Time factor is the main drawback of this research technique. Algorithm implementation and image processing techniques are coupled with neural network to identify the tumor whether it is gentle or cruel [29]. Images are preprocessed with non-linear total variation algorithm or optimal threshold approach [19]. The developed system can able to find cancerous cells within 3 minutes. It is limited to small input image set. It can be enhanced for large image set. Katrina Palmer Lee et.al (2012) [9] proposed iterative image restoration method, implements an efficient matrix vector multiplication, and linear system solvent for preconditioning the tedious in time overshadowing way.

This work describes a set of MATLAB tools that hide these complicated implementation details [7]. Combining the powerful scientific computing and graphics capabilities in MATLAB, with the ability to do object oriented programming and operator overloading, results in a set of classes that is easy to use, and easily extensible. This Research work reviews a result from a comparative study of Wiener filter and Intelligent Water Drop (IWD) technique for removal of speckle noise [13]. Image restoration methods conclude the time consuming problem. The method uses five metrics such as average absolute difference, signal to noise ratio, peak signal to noise ratio, image fidelity and mean squared error value for measuring the performance to compare and analysis the results [8]. Principal components analysis (PCA) is the pruning technique used for improving the quality of restoration. The implementation of the IWD based image restoration obtains the higher peak signal-to-noise ratio (PSNR) value and improves the quality of an image and increases the peak signal-to-noise ratio (PSNR) value.

III. MATERIALS AND METHODS

For the image preprocessing, a number of techniques applied on the chosen image data set in the application areas of image processing. This work is basically concentrated to develop a technique to enhance the Lung image suitable for further diagnosis. The selected digital MRI has become the most effective technique for early detection of lung cancer. The MRI images used in this research work are real time image collected from Gemini Scans [9]. The images are arranged in pair of MRIs where each pair represents the left and right lung of a single patient. Two categories of images are available in the data set, which are beige and malignant.

Image enhancement technique is as a process of an image processing such that the result is much more suitable than the original image for a specific application. This improvement of the stored digital image is done with the help of the MATLAB software [10]. The proposed approach is depicted in Figure-1.

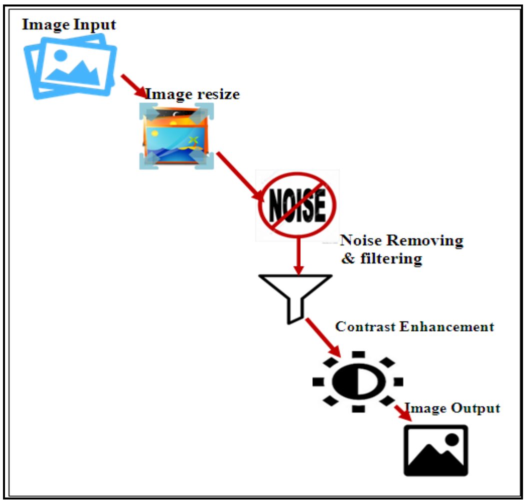


Figure 1. Preprocessing Methodology

The steps proposed in the preprocessing technique are (Simultaneous, Noise Removal, Filtering and Contrast Enhancement)

1. The real time MRI image is acquired from the Gemini scan centre.
2. The Color image is converted to Gray scale image.
3. The images are resized into different size.

4. Noise from the gray image is removed by using various filtering technique.
5. Contrast of the image is enhanced by applying the Adaptive Histogram Equalization for filtering technique.
6. The obtained image is the enhanced output image.

A. Pre-processing

The raw images collected from the scan centre and the websites are not suitable for direct processing due to various noises present in these images. Therefore it is necessary to pre-process it before examining. Pre-processing is an important step used in MRI, label, artifact removal, enhancement and segmentations [11]. The preprocessing involved in conversion, image resize, noise removing and enhances the quality and produces an image in which minutiae can be detected correctly [20].

Gray Scale Conversion: The filtering techniques such as power spectra and blur filter are adapted for noise removal technique. It is easy to see that the Wiener filter has two separate part, an inverse filtering part and noise smoothing part. It not only performs the de-convolution by inverse filtering (high pass filtering) but also removes the noise with a compression operation (low pass filtering) [28].

Image resizes: Image resizing is an important role in image processing technique, to enlarge and reduce the given image size in pixel format. Image interpolation can be divided into two different ways, they are image down-sampling and up-sampling which is necessary when resizing the data for matching either the specific communication channel or the output display [12]. While it is more efficient to transmit low resolution versions to the client, an approximation of the original high-resolution may be needed for presenting the final visual data. An accurate resizing of image data is an essential step in many applications, ranging from several consumer products to critical functions within the medical, security, and defense sectors. Nearest neighbor algorithmic technique was implemented in this section as one of the part of image resizing technique [25]. The implementation of nearest neighbor technique makes the final process very fast for processing image. The speed of resizing can be calculated with the use of procedure suffers from the fact that the resulting image often contains block artifacts, which are not very visually noticeable but typically can also drastically negatively affect, error calculations used to compare methods. Two additional techniques commonly used are bi-linear and bi-cubic interpolation [13].

Noise Removal: Image noise is defined as the random variation of brightness or color information in images produced by medical devices or scanners. Image noise is generally regarded as an undesirable by product during image acquisition. Noise is often defined as the uncertainty in a signal due to random fluctuation in that signal [14]. There are many causes for these fluctuations. All medical images contain some visual noise. The presence of noise gives an image a mottled, grainy, textured, or snowy appearance. Several types of noise exist and the most common noise found in medical images is explained below.

Salt and pepper: Salt and pepper image conversion technique are commonly used as a part of image noise removal technique [24]. It represents itself as randomly occurring white and black pixels. Salt and pepper noise creeps into images in situations where quick transients, such as faulty switching take place. It is also known as “impulsive noise” or “spike noise”.

Gaussian: Gaussian noise is statistical noise that has a probability density function (PDF) of the normal distribution, also known as Gaussian distribution [15]. In Gaussian noise, each pixel in the image will be changed from its original value by a (usually) small amount.

Shot or Poisson: Short noise, otherwise known as Poisson noise, is the dominant noise in the lighter parts of an image. An image sensor typically causes statistical quantum fluctuations, that varies in the number of photons sensed in the given exposure level; this noise is known as photon shot noise [23].

Speckle: Speckle noise is a granular noise that inherently exists in and degrades the quality of the active radar and synthetic apertures radar images [16]. This type of noise is usually seen in ultrasonic medical devices.

B. Filtering Methods

Filtering technique for enhancing an image, in filters are mainly used to suppress either the high frequencies in the image, i.e. smoothing the image, or the low frequencies, i.e., enhancing or detecting edges in the image [17]. For example, you can filter an image to emphasize certain features or remove other features. Numbers of techniques are available and the best options can depend on the image and how it will be used. Image filtering is useful for many applications, including smoothing, sharpening, removing noise, and edge detection.

Wiener: The wiener filtering executes an optimal tradeoff between inverse filtering and noise smoothing. It removes the additive noise and inverts the blurring simultaneously. The Wiener filtering is optimal in terms of the mean square error. In other words, it minimizes the overall mean square error in the process of inverse filtering and noise smoothing [18]. The Wiener filtering is a linear estimation of the original image. The approach is based on a stochastic framework. The orthogonality principle implies that the Wiener filter in Fourier domain can be expressed as follows:

$$f(x,y) = \frac{H*(f_1,f_2)S_{xx}(f_1,f_2)}{H(f_1,f_2)2S_{xx}(f_1,f_2)+S_{nn}(f_1,f_2)}$$

Median: Median filter works on a rectangular region. It changes the size of images during the filtering operation depending on certain conditions as listed below. Each output pixel contains the median value in the 3-by-3 neighborhood around the corresponding pixel in the input images. Zeros however, replace the edges of the images [19]. The output of the filter is a single value, which replaces the current pixel value at (x,y) the point on which S is centered at the time. The following notation is used.

Z_{min} = Minimum pixel value in

Z_{max} = Maximum pixel value in

Z_{med} = Median pixel value in

Z_{xy} = Pixel value at co − ordinates (x

S_{max} = Maximum allowed size of

Median filtering used to smooth the non- repulsive noise from two-dimensional signals without blurring edges and preserved images. This makes, it particularly suitable for enhancing MRI images. The median filter performs spatial processing to determine which pixels in an image have been affected by impulse noise. The median filter classifies pixels as noise by comparing each pixel in the image to its surrounding neighbor pixels. The size of the neighborhood is adjustable, as well as the threshold for the comparison. A pixel that is different from a majority of its neighbor, as well as being not structurally aligned with those pixels to which it is similar, is labeled as impulse [19]. These noise pixels are then replaced by the median pixel value of the pixels in the neighborhood that have passed the noise labeling test.

Gaussian : Gaussian filter plays the most important role in both theory and applications. Gaussian filtering is a commonly used image filtering technique which is a WAP with weight defined as

$$W_{ij}\,\alpha\,\exp\left(\parallel x_i - x_j \parallel\right), i \neq j$$

W_{ij} =Where determines the distance of the rapid decay. Gaussian smoothing is effectively a local filtering method. As an image denoising algorithm, Gaussian filter is well known to over smooth images, resulting in the loss of significant detail, especially edge sharpness [21]. Gaussian smoothing is low-pass filtering, which suppresses high-frequency detail which includes noise and also edges, while preserving the low-frequency components of the image, which don't vary too much [20]. In other words, the filter blurs everything that is smaller than the feature of image.

C. Contrast Enhancement

Contrast is the difference between maximum and minimum pixel intensity. The formula for stretching the histogram of the image to increase the contrast is

$$g\ (x, y) = \frac{f(x, y) - fmin}{fmax - fmin} * 2^{bpp}$$

The formula requires finding the minimum and maximum pixel intensity multiply by levels of gray. In our case the image is 8bpp, so levels of gray are 256.

The minimum value is 0 and the maximum value is 225. So the formula in our case is

$$\mathrm{g}\ (\mathrm{x,y}) = \frac{\mathrm{f(x,y)} - 0}{225\ - 0} * 255$$

where f(x,y) denotes the value of each pixel intensity. For each f(x,y) in an image , we will calculate this formula.

After applying the equations the ability of the image is enhanced by improved. The major objective of the contrast enhancement system is twofold; locally adaptive histogram equalization and reduction of undesired objects such as noise and blocking object [22]. More specially, local adaptively is incorporated by block-based processing technique, blocking artifact is reduced by overlapping adjacent blocks, and noise suppressed by spatio-temporally adaptive filtering. The detail of block-overlapped histogram equalization algorithm is summarized as follows without considering image boundary.

The relationship between the entire image and the (m ,n) block is represented in figure-3, where the histogram equalization is performed on the corresponding B x B block, and the intensity of the centre pixel in the block is transformed according to the equalization. In order to compute the histogram of the next block, that is (m, n+1) block, we just add the last column of the new block and discard the first column of the old block [26].

IV. Experimental Results and Discussion

Image resizing: Enlarge or reduce the image size (number of pixels) .Image down sampling (resample at a lower rate) reduces a 512x512 image to 256x256 equals factor of 2 down sampling in both horizontal and vertical directions. Image up-sampling (resample at a higher rate) produces a larger image from a smaller one 512x512 -> 1024x1024.

Image shrinking, derive everything in 1D. Shrinking of a two dimensional image is done in two steps: first in x direction, then in y direction. Shrinking by a factor a < 1: pixels as "fat pixels"; the size of a fat pixel is 1/a; the size of a the (rescaled) target image is aw (1/a) = w = size of the original (but the pixel size is different)

Image stretching is done by the factor of a > 1; the size of "tiny pixel is 1/a; the size of a (rescaled) target image is aw (1/a) = w = size of the original.

The original image for the preprocessing work taken for this analysis is given the figure 2(a). The preprocessing techniques such as Image resizing, Noise Removal, Filtering and Contrast Enhancement are carried out. After preprocessing the image, the results of the images in various frame sizes are given in the figures 2(b) to 2(d). Table 1 contains the number of pixels in each and every stage of the results of preprocessed images. Also, table 1 has the memory space taken for storing the images for various sizes of the images.

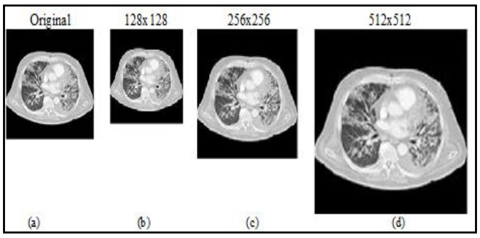


Figure 2. Results of Image Sizes

TABLE I. IMAGE PIXEL COUNT

Image Size	Space Occupied (KB)	No. of Pixels
227X222	55.9	50394
128x128	3.26	16384
256x256	11.5	65536
512x512	40.5	262144

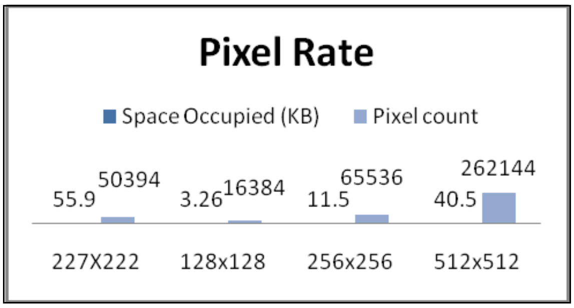


Figure 3. Pixel Rate

The original color image obtained for analysis is given the figure 4(a). It is easy to identify that the Gray scale has two separate part, an inverse filtering part and noise smoothing part which is shown in figure 4(b). .

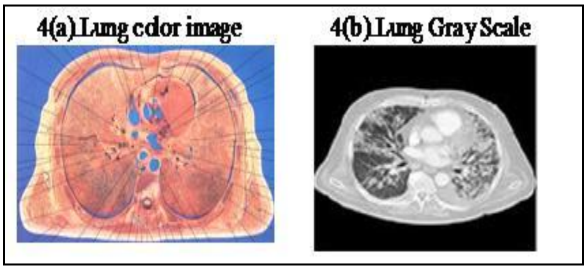


Figure 4. Result for Gray Scale conversion

Result for Salt and pepper noise Removal

An image containing salt and pepper noise will have dark pixels in bright regions and bright pixels in dark regions. This happens due to analog to digital conversion error, transmission bit errors, dead pixels etc. It can be eliminated by using dark frame subtraction and by interpolating around dark bright pixels.

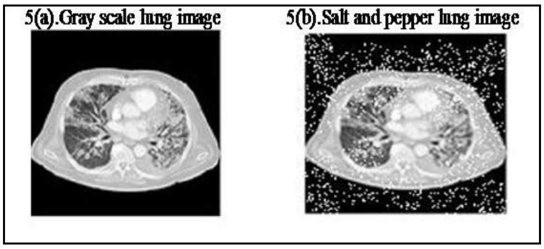


Figure 5. Salt and pepper noise Removal

Result of Gaussian Low pass filter

In Gaussian noise removal, each pixel in the image will be changed from its original value by a (usually) small amount. Low pass filtering removes noise with a compression operation as shown below

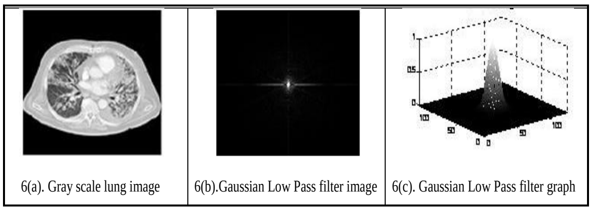


Figure 6. Gaussian Low pass filter

Result of Gaussian High pass filter

Gaussian noise is statistical noise that has a probability density function (pdf) of the normal distribution, also known as Gaussian distribution. In Gaussian noise, each pixel in the image will be changed from its original value by a (usually) small amount. Gaussian High pass performs the de-convolution by inverse filtering as shown below.

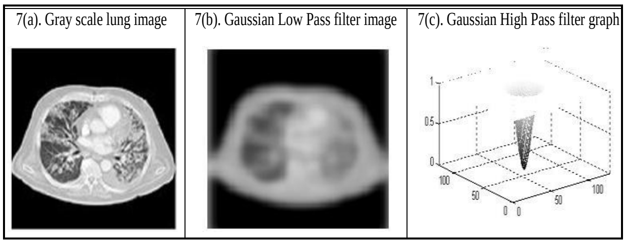


Figure 7. Gaussian High pass filter

Result of Histogram Equalization

Histogram equalization is used to adjust the contrast of a gray scale image. The original image has low contrast, with most pixel values in the middle of the intensity range. It produces an output image with pixel values evenly distributed throughout the range. Histogram Equalization is a straightforward image-processing technique used to achieve better quality images in black and white color scales in medical applications. (MRIs, CT scans and digital X-Rays)

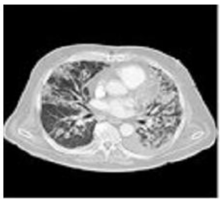
8(a). Before Contrast Enhancement	8(b). After Contrast Enhancement
	

Figure 8. The performance of Histogram Equalization

The experiment result that is obtained by applying the previously described Wiener filtering, Median filter, Gaussian filter are shown in Figure-9 . The experimental results shown are the pre-processed images for contrast enhancement process.

Various stages in lung cancer image preprocessing techniques are shown with below images. The dimension and pixel of the original image are 227 x 222 length and width, 50394 pixels.

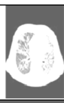
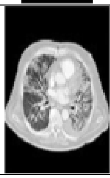
Methods	Wiener Filter	Median Filter	Gaussian Low and High Pass Filter
128 x 128			
256 x 256			
512 x 512			

Figure 9. Filtered image with different size

The Filtering Techniques Wiener Filter, Median Filter and Gaussian Low and High Pass Filter are deployed with various methods. The Result obtained can be clearly observed from Table 2. The observed results are very clear in explaining the size variation of image and techniques deployed can alter the image clarity.

TABLE II. FILTERING TECHNIQUES AND RESULT OBSERVED

Method	Filtering Technique	Results Observed
128 X 128	Wiener Filter	Small size and Dark
	Median Filter	Small size and Bright
	Gaussian Low and High Pass Filter	Small size and Clear
256 X 256	Wiener Filter	Medium size and Dark
	Median Filter	Medium size and Bright
	Gaussian Low and High Pass Filter	Medium size and Clear
512 X 512	Wiener Filter	Large size and Dark
	Median Filter	Large size and Bright
	Gaussian Low and High Pass Filter	Large size and Clear

After deploying filtering process enhancement techniques are implemented with histogram equalization by adapting overlapping histogram equalization.

V. CONCLUSION

The research work focuses on preprocessing lung images. The preprocessing technique deployed in this research work removes the unwanted noise and enhance the quality of the image by applying various filtering techniques. Various image filtering techniques like Wiener, Median, and Gaussian are used for this research work. The results are analyzed and compared with standard pattern of noises and also evaluated through the quality. The observation of this research work is to focus on choosing the correct filtering techniques and removing the noise by considering the type of lung images. The deployed preprocessing technique not only reduces the time, it also compares the three types of filters and observes median filter for best pixel result. The resultant lung images gathered from this process can be helpful for carrying forward this research work. The gathered images can be analyzed with proposed algorithm in time consuming way.

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