Preprocessing for HRCT images of Interstitial Lung Disease

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***Abstract*— Digital image processing has pulled in numerous specialists because of its noteworthy exhibition progressively applications, for example, biomedical frameworks, security frameworks and automated computerized diagnosis frameworks. The various illnesses including interstitial lung diseases (ILD) determination are finished with the assistance of automated tissues characterization. The different sorts of illnesses present in the lungs were not many of the may prompt leave the scars. Identified scars may have diverse patterns. Depending upon patterns occurred in the image different features and classifiers are used to categorize the different layers. Preprocessing is essential to address and modify image for additional investigation and processing. Preprocessing available with the different types of filtering techniques. This filters used to remove the noise, improve image quality, saves the edges inside a image, enhance and smoothen the image. In this paper, we have performed different filters namely, mean filter, median filter, wiener filter and adaptive median filter. The performance of images analysis compared with image quality metrics such as Peak Signal-to-Noise Ratio (PSNR), Root Mean Squared Error (RMSE) and Structural similitude record measure (SSIM).**

***Keywords*— ILD, image quality metrics, PSNR,RMSE,SSIM**

I. INTRODUCTION

An inside perspective on human body in a noninvasive manner gives to clinicians by Medical imaging. In addition, it gives an increasingly anatomy perspective on the life structures influenced by the infection, empowering a progressively exact, fast analysis and exact treatment choices. Hence, medical imaging has become the standard way to deal with surveying all critical ailments and illnesses Interstitial lung disease (ILD) or diffuse parenchymal lung disease (DPLD) is a condition that outcomes in dynamic powerlessness to keep up typical blood oxygen levels because of disabled exchange of gas over the alveolar-slender film [1]. Interstitial lung disease may be realized by long stretch introduction to hazardous materials, for instance, asbestos or coal build up, or it will in general be achieved by an auto-insusceptible affliction, for instance, rheumatoid joint irritation. At the point when lung scarring occurs, it's regularly irreversible. Signs join a dry hack, Brevity of breath can happen either exceptionally still or after exertion. Treatment relies upon the fundamental reason anyway as often as possible consolidates steroids. It also causes stiffness in the lung tissues, reduces ability to carry oxygen to blood stream and remove carbon dioxide [2]. However, ILD subtypes have different prognoses and treatments, so a correct diagnosis is essential [3].

Consistently requires a remedial assurance, Lab tests or imaging. Chest radiography is ordinarily the principle test to perceive interstitial lung diseases; anyway the chest radiograph can be standard in up to 10% of patients, especially at a beginning period the illness method. X-rays is restricted in the finding of certain infections because of the superimposition of various structures. Computer aided diagnosis (CAD) of lung CT (computer tomography) images has been a progressive advance in the early stage as well as premature detection of lung abnormalities. Presently a day's the HRCT (High resolution computer tomography) provides more resolution than the conventional CT chest, allowing the HRCT to elicit details that cannot otherwise be visualized [4].Other imaging procedures, for example, positron emission tomography (PET)- CT and magnetic resonance imaging (MRI) might be utilized. Drawbacks with these methodologies as MRI has a poor sign to noise proportion extent in the lung and use of PET can require an on the spot cyclotron and radioisotope with short half-life. Suggest that they are not commonly used, and are correct presently obscured by HRCT as the imaging technique of choice for ILD characteristic and prognostic purposes.

The ILD is arranged into four clinically unmistakable gatherings: (1) ILD of known affiliation (e.g., collagen vascular ailment, extreme touchiness pneumonitis auxiliary to exposures), (2) granulomatous ILD (e.g., sarcoidosis), (3) other rare ILDs (e.g., lymphangioleiomyomatosis, pulmonary Langerhans cell histiocytosis), and (4) idiopathic diseases (idiopathic interstitial pneumonias [IIPs]) [5, 6].

The Figure 1, shows different ILD patterns. ILD patterns typical in CT images are: reticulation, honeycombing, ground glass opacity (GGO), consolidation and micronodules. Different feature extraction methods are used right from the beginning of ILD classification.

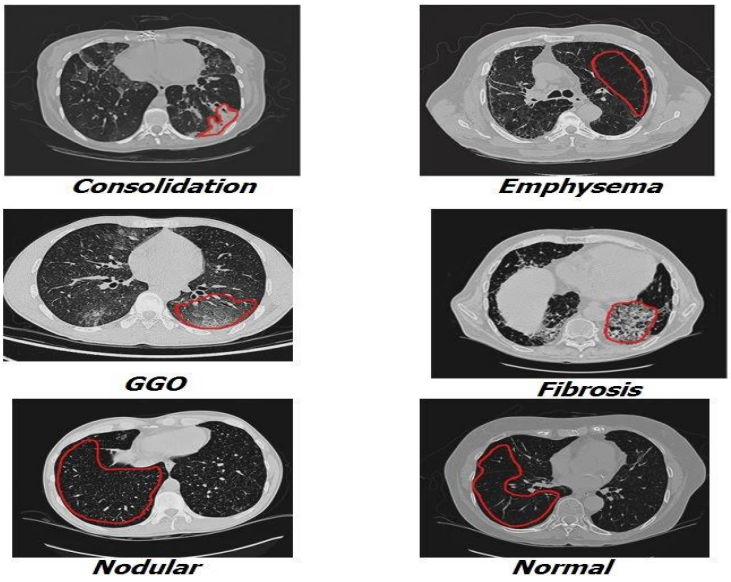


Figure 1: Different ILD patterns

II. RELATED WORK

This segment contain the related work on preprocessing system proposed on Lung images alongside their exhibition parameters examined.

Low pre-processing techniques based on Gabor filter within Gaussian rules[7] gives the Enhancement percentage =80.735%.In [8] Gaussian filter, median filter, wiener filter with Gaussian and speckle noise and found that Wiener filter gives better result with parameters PSNR=22.8086, MSE=0.0052. Adaptive Median Filter, Alpha Trimmed Mean Filter, Gaussian filter, Gabor filter, HPF, Laplacian filter, Bilateral filter compared in [9] and Bilateral filter gives PSNR=88. 23 and MSE= 0. 000379. Ordered filter, median filter, wiener filter proposed [10] and Median filter gives PSNR=28.1666. [11] presented Gabor filter, auto-enhancement, FFT filter compared, Gabor filter enhancement percentage=80.735%. [12] gives salt-and-Gaussian (GN), Poisson (PN),speckle (SK) noise and noise removal filters, mean filter (MF),Adaptive median(AMF) filters comparisons. Presented[13] Wiener Filter, Median Filter and Gaussian Low and High Pass Filter(HPF), median filter for best pixel result.[14] Median filter, Gaussian filter, wiener filter performance compared and found that, Wiener filter Entropy=6.7878, PSNR=28.9782, MSE=35.8529. Proposed[15] combination of two models such as Gaussian conditional random field (GCRF) and Multinomial logistic regression (MLR) gives PSNR=27.89.In[16] adaptive median filter, mean filter, median filter compared with parameters as Speckle suppression index(SSI)Speckle suppression and mean preservation index (SMPI). One of the most mainstream techniques is the Histogram Equalization (HE). In any case, during the time spent improving a picture, HE radically changes the normal splendor of the picture, bringing about loss of data and outwardly decayed pictures [17]. All images were first processed with the initial automatic lung segmentation based on thresholding and morphology. severe cases where the initial segmentation was erroneous was enhanced with normalized graph cut is done in[18]. The comparison of watershed segmentation and FCM segmentation is done[19].

watershed segmentation yielded over segmentation and no signs of cyst area can be notified. FCM segmentation yielded better result with higher accuracy of cyst region segmented and less over-segmented region detected.

III. MATERIAL AND METHODS

The overview of the detection of the ILD from the database is shown in the Figure 2.

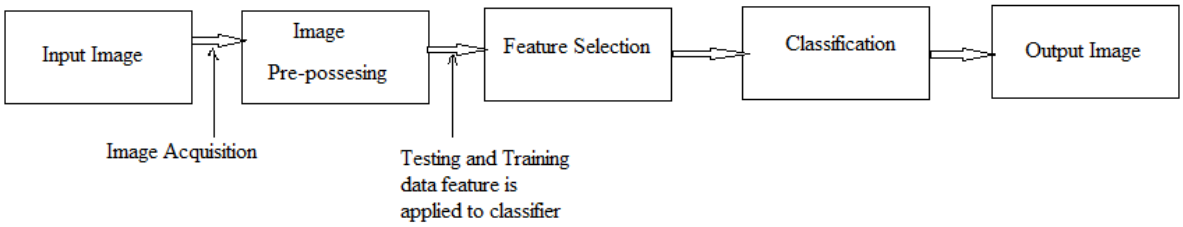


Figure 2: Overview of the detection of the ILD

For performing the classification the test image (input image) having ILD patterns are used. With reference to width and height the rescaling of images is done. Further operations performed on the preprocessed image. Preprocessing is the decisive step of every image processing applications. It is needed to enhance the image generally by removing the noise and adjusting the contrast in it. Firstly, the region of interest selection (ROI) for diagnosis is done. By choosing a rectangular shape this is possible. The feature extractions from the patches formed are done. Next step is the classification section done by using efficient classifier.

The normal qualities of the medical images like as weak boundaries and unrelated parts will affect the content of the medical images, noise, poor image contrast, in homogeneity. This issue redressed by preprocessing methods. The preprocessing are central strides in the medical image handling to create better picture quality for segmentation and feature extractions. The preprocessing steps manage image enhancement, noise and special mark removal. The further stage of processing as image segmentation is as automatic and semiautomatic medical image segmentation.

The noise, poor image differentiate, in homogeneity, frail limits and exceptional imprint existing in the medical image division process amazingly hard to expel the commotion and extraordinary markings that exist in clinical pictures [20],[21].

PREPROCESSING

The principle objective of the preprocessing is to improve the image quality to prepare it to further processing by removing or reducing the unrelated and surplus parts in the background of medical images that complicated to interpret. Consequently preprocessing is basic to improve the quality. It will set up the ILD images for the following two-process segmentation and feature extraction. The performance of final stage that is classifier depends on initial stages. The noise and high recurrence parts evacuated by filters.

A. Mean filter or average filter

The objective of the mean filter used to improve the image quality for human observers. In this, filter supplanted every pixel with the normal estimation of the powers in the area. locally reduced the variance, and easy to carry out [20]. Restrictions of mean filter is that Averaging tasks lead to the blurring of an image and features localization affects by blurring, A solitary pixel with an unrepresentative worth influenced the mean estimation of the considerable number of pixels in neighbourhood essentially.

On the off chance that the averaging tasks applied to a image debased by impulse noise, the motivation noise weakened and diffused yet not evacuated.

B. Median filtering

A middle channel is a nonlinear channel is productive in evacuating salt and pepper commotion middle will in general keep the sharpness of picture edges while expelling noise. The few of middle channel is I) Center-weighted middle channel II) weighted middle channel III) Max-middle channel, the impact of the size of the window increments in middle sifting noise expelled viably.

C. Wiener filter

The wiener filter attempts to assemble an ideal gauge of the first image by upholding a base mean square mistake limitation among gauge and unique picture. The wiener filter is an ideal channel. The goal of a wiener filter is to minimize the mean square error. A wiener filter has the capacity of dealing with both the corruption work just as noise. From the degradation model, the error between the input signal f(m, n) and the estimated signal f(m, n) is given by

$$E(M, N) = F(M, N) - F(M, N) \quad (1)$$

The square error is given by

$$[F(M, N) - F(M, N)]^2 \quad (2)$$

The mean square error is given by

$$E\{[F(M, N)-F(M, N)]^2\} \quad (3)$$

D. Adaptive median filter

Adaptive median filter works takes a shot at a rectangular area Sxy. It changes the size of Sxy during the sifting activity relying upon specific conditions as recorded underneath. Each yield pixel contains the middle an incentive in the 3-by-3 neighbourhood around the comparing pixel in the info pictures. Zeros however, replace the edges of the images [23]. The yield of the filter is a single value, which replaces the present pixel esteem at (x, y), the point on which S is focused at that point. The following notation is used:

Zmin = minimum pixel value in Sxy
Zmax = maximum pixel value in Sxy
Zmed = median pixel value in Sxy
Zxy= pixel value at coordinates (x, y)
Smax = maximum allowed size of Sxy

Adaptive median filter used to smooth the non-repulsive noise from two-dimensional signs without obscuring edges and protected pictures.

IMAGE QUALITY METRICS

Root mean square error (RMSE) is the square root of difference between original and reconstructed image.

$$RMSE = \sqrt[2]{\frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j)-K(i,j)]^2} \quad (4)$$

Peak Signal to Noise Ratio (PSNR) this metric is used to measure the quality with that of the original or corrupted image.

$$PSNR = 10log_{10}\, snr \quad (5)$$

Structural Similarity Index Measure (SSIM) is a method for measuring the similarity between the original image and reconstructed image.

$$SSIM = \frac{(2u_x\mu_y+C_1)(2\sigma_{xy}+C_2)}{(\mu_x^2+\mu_y^2+C_1)(\sigma_x^2+\sigma_y^2+C_2)} \quad (6)$$

ALGORITHM-A (for Filtering method)

Step 1: Take a input image.
Step 2: Process the image with the following filter techniques:
1.Mean filter
2.Median filter
3.Wiener filter
4.Adaptive median filter
Step 3: Evaluate the PSNR, RMSE and SSIM values.
Step 4: Select the filter which gives high PSNR, low RMSE and high SSIM values.
Step 5: Stop the process.

IV. EXPERIMENTAL SETUP AND PERFORMANCE ANALYSIS

Implemented using MATLAB 2017b tool. A publicly available ILD database for validation [24]. It consists of 108 HRCT volumes corresponding to 13 histological diagnoses of ILDs. In this dataset healthy, consolidation, emphysema, fibrosis, groundglass, micronodules pattern images available. Implemented using MATLAB 2017a tool.

Figure 3, shows the output of some ILD image patterns using filtering methods such as mean filter,median filter, wiener filter, adaptive median filter. Also the quality of image is compared by using different quality metrics such as PSNR, MSE and SSIM. The value of PSNR should be high and MSE must be low. The SSIM index value should be high.

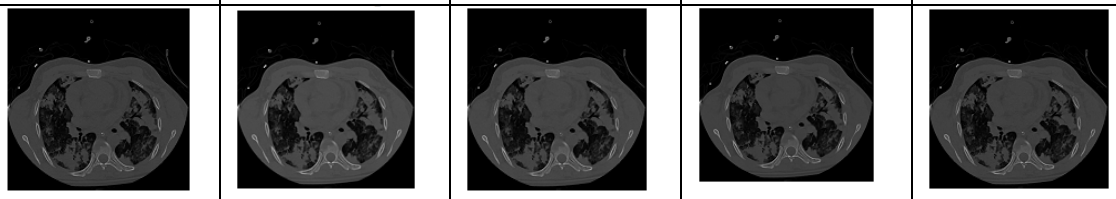
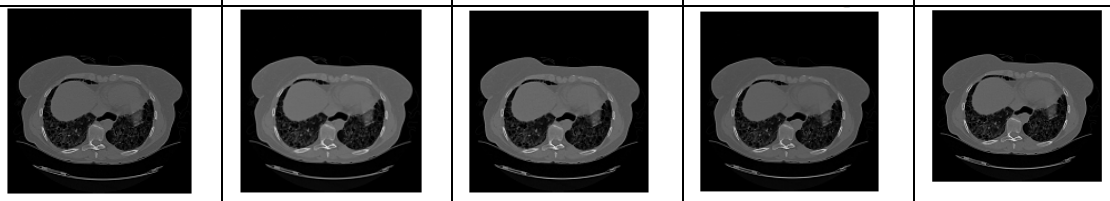
Original Image	Filter Techniques			
	Mean filter	Median filter	Wiener filter	Adaptive Median filter
consolidation				
emphysema				
fibrosis				

Figure 3: Original images filtered images with different methods

Different ILD patterns are filtered using filtering techniques such as mean filter, median filter, wiener filter and adaptive median filter. As shown in Table 1, different image quality metrics with filtering techniques. It shows that the adaptive median filter gives good performance.

Table 1: Image quality metrics using different filtering techniques.

Image Quality Parameters	Filter Techniques	Patterns		
		Consolidation	Emphysema	Fibrosis
PSNR	Mean filter	22.8420	21.2224	22.2952
	Median filter	24.5328	22.7717	24.3556
	Wiener filter	27.1159	25.4229	28.3035
	Adaptive Median filter	28.2892	26.2386	28.3208
RMSE	Mean filter	73.2327	80.3034	64.8860
	Median filter	61.8411	68.7780	52.8040
	Wiener filter	47.7633	52.7602	35.5806
	Adaptive Median filter	42.4753	48.6274	35.5192
SSIM	Mean filter	0.5322	0.5194	0.4604
	Median filter	0.5322	0.5298	0.4506
	Wiener filter	0.5683	0.5673	0.4925
	Adaptive Median filter	0.7088	0.7548	0.6359

V.

CONCLUSION

The preprocessing is the important stage for further ILD image analysis. In this paper the ILD image with different patterns are preprocess by filtering techniques such as mean filter, median filter, wiener filter and adaptive median filter. The performance analysis is with parameters such as PSNR,RMSE and SSIM. From the results it evaluated that the adaptive median filter gives high PSNR , low RMSE and high SSIM. In future this filter ILD images utilize for other preprocessing such as enhancement methods and this preprocess images can be use for next stages of ILD image analysis such as segmentation and feature extraction. Also performance can be compared with different segmentation techniques.

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