Lung Cancer Detection and Classification using Curvelet Transform and Neural Network

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Abstract— Lung cancer is the most acute type of cancer among all the cancers with less survival rate. It is very difficult to analyze the cancer at its early stage. In the past few years, many Computer aided systems have been designed to detect the lung cancer at its early stage. The most of work is implemented on the Computer Tomography (CT) scan images because of better clarity, low noise and distortion. In this paper, Lung cancerous cells are detected using the curvelet transform and with the help of the Artificial neural network Classification is done whether it is benign or malignant.

Key words: Lung Cancer, Curvelet Transform, Neural Network

I. INTRODUCTION

Lung cancer is the type of cancer that begins in the lungs. The lung cancer causes the maximum cases of deaths in Men and Women among the all cancers. In United States 164,000 people die with lung cancer every year [1]. In a survey ,in males more than 80% and in females more than 70% lung cancer is caused by Cigarette smoking [2].According to the latest survey in year 2014, total 159,260 people had been died due to lung cancer in US [3].In INDIA every year 63,000 new lung cancer cases has been reported[4]. Detection of the cancer at the early stage is very difficult so Various CAD systems have been designed for the detection of the lung cancer at the early stage. Diagnose of the lung tumor at the early stage can increase the survival rate of 1 to 5 years.

The lung tumor causes due to an abnormality in body cells.The human body checks and maintains the growth of cells in order to produce the new cells whenever they are required in Human Body. Due to growth of cell, the unbalance of the system results in uncontrolled division and proliferation of cells due to which a mass is formed, known as a tumor. Tumor can be two types: it can be malignant or benign . A tumor which can be removed and can be stopped spreading in other parts of the body, is type of benign tumor. Another part of Tumor which grows aggressively and spread into the other parts of the body is known as malignant. Instead of using invasive method like Biopsy, medical imaging is preferred to look inside the body because it is safe and comfortable for the effected person. For the nodule detection and treatment of lung cancerMedical Imaging plays a very important role. This method is more accurate and efficient method for the diagnosis compare to other In medical Imaging different types and formats of images are being used, but Computed Tomography (CT) images are being preferred for detection of lung diagnosis because of low noise,better clarity and less distortion. This method is also important compare to other images in terms of calculation of mean and variance of images. The Whole Work is divided into two Parts Image Segmentation and Image Classification. In all the Processes Lung Segmentation is considered as the most difficult part because it includes various pre-processing steps. Image Classification is done using the artificial Neural Network.This Research paper includes the detection of the Cancerous cells in the Lung and Classification of the Cancerous Cells.

II. PREVIOUS WORK

Mokhled [5], discussed the various lung tumor detection techniques for different stages. He Proposed three methods for image enhancement, to remove the noise from the image and to make the image better: Gabor filter is more efficient because it can effectively optimize the border differences among the lung regions. To separate the region image segmentation is required like watershed algorithm. To differentiate the extracted region from the lung structure binarization and masking approaches were proposed. In binarization, if the total numbers of black pixels were less than threshold value, then it was classified as abnormal otherwise normal. mass was referred when white area inside the lung is considered . Blue color of the mass shows normality while RGB shows the abnormalities of the mass. On the basis of these features, system classification accuracy was less.

Disha, Gagandeep [1], proposed a CAD system in which wiener filter was used to remove the noise content. In Her Research work she applied image slicing algorithm For extraction of lung region, author enhance the quality of image using various morphological operations like closing, opening followed by erosion, dilation which were applied to remove any irrelevant information in the images. With image segmentation each and every pixel were assigned a label so that the pixels that have same label, represent visual characteristics.Image segmentation is basically represent a set of contour (edge detection).Sobel method was used for the edge detection because of its accuracy and two dimension values of the pixels so that no pixel can be left nearby. In this paper, five features (area, calcification, shape, size, contrast Enhancement) were extracted on the basis of which the ROI was classified as tumor or non-tumor.

III. THE CURVELET TRANSFORM

Curvelet Transform is a tool for analysis of multi resolution of Image Compare to the wavelet transform because wavelet transform has a limitation of singularity point detection while curevelettransform is more powerful at the curved singularities. So Curvelet transform is better at the image compression image denoising and tumorDetection. To Overcome the limitation of the wavelet transform Curvelet

transform is developed by candles and et[5] for efficient representation of smooth objects with discontinuities along curvelet in 2000.Curvlet transform is designed to represent edgesand other discontinues along curves more efficiently compare to wavelet transform .Basic Function of curvelet transform have needle shape and have more sensitivity and anisotropy at the edges . Curvelet transform used rectangular window which required small coefficients compared to other transformed Curvelet transform are two different types namely unequally spaced fast Fourier transform(USFFT) and wrapping based fast curvelet transform. In our research work curvelet coefficients are obtained using wrapping based curvelet transformed because it is faster in computation time and more robust than Ridgelet transform and USFFT transform [5].

Figure 1 indicates the comparison of wavelet and curvelet in terms of coefficients at the curved parts.

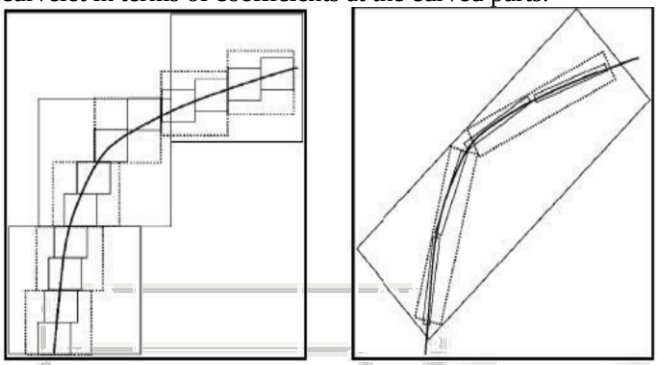


Fig. 1: Comparision of Wavelet and Curvelet Transform

The wrapping based curvelet transform takes 2D image as a inputfrom a Cartesian array F[m,n] where M,N are the dimension of the array

$$c^D(j,l,k_1k_2) = \sum_{\substack{0\le m<M \\ 0\le n<N}} f[m,n]\varphi^D_{j,l,k_1k_2} \qquad (1),$$

As shown in equation (1) the output is the curvelet coefficients indexed by scale j and orientation l and spatial location parameter K_1 and K_2.

Where ,$\emptyset^D_{j,l,k1,k2}[m, n]$ is the curvelet transform. In the following Equations the Curvelet transform is described (2)

Curvelet Transform= InverseFFT[FFT(curvelet) X FFT(Image)] (2)

And the product from this two is multiplication of wedge. The Procedure for the Extraction of the features from the Input database is explained in section of proposed method Section.

IV. NEURAL NETWORK

Artificial Neural Network (ANN) is the computational models which are motivated by human brains and capable of machine learning and pattern Recognization using training and testing phase. The internal architecture of the Neural Network is capable of solving variety of Problems related to Image Processing like, Image Compression, Image Segmentation, Pattern Recognization Feature Extraction and Image Classification. A Neural Network is defined as [8]

"A neural network is massively parallel and distributed processor made up of simple processing units, which have natural propensity for storing experimental knowledge and making it available for future use"

Neural Network consist of three main layers for image classification input layer ,Hidden layer and output layer.

Neural network are basically two types feed backward network and feed forward network in this research feed forward network is used for the classification.

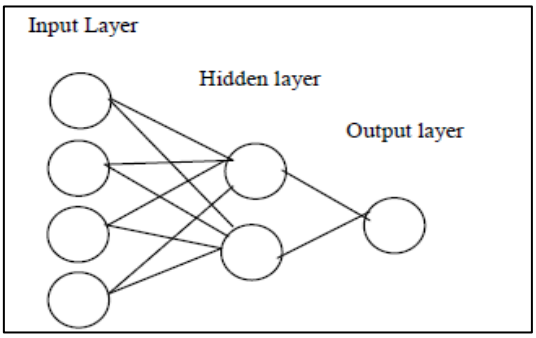


Fig. 2: Feed Forward Neural Network

V. RESEARCH METHODLOGY

Lung cancer Detection and Classification Research Work is divided in to Two Parts . I in the First part Cancerous Cells are detected using the curvelet transform and canny edge detection with the morphological operations. While in the second Part Consist of Image Classification using Extracted features from the curvelet transform and Neural Network. Flow of the Different steps is shown in the Figure 4 Below.

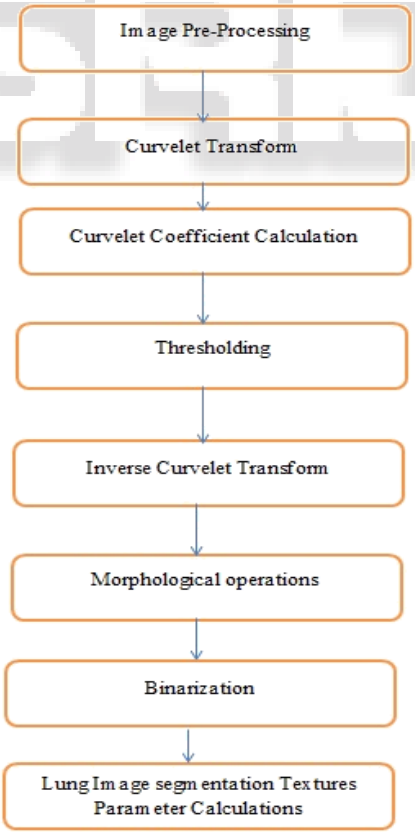


Fig. 3: Part I .Lung Cancer Detection

A. Image Pre-Processing

Input Database is taken from Public Data Base center VIA/I-ELCAP Public Access Research Database, VIA Group,

Cornell University[]. Input Images are in the form of DICOM Images so Input Medical Images are converted into Gray scale Image format. After that Pre-Processing is done on the input database using median filter which is used to remove noise and unnecessary information from the medical image like patient name. To enhance the contrast of images, histogram equalization is used in numerous applications. The drawback of histogram equalization is that the image brightness is changed after apply this technique. To overcome the limitation of histogram equalization we used Contrast Limited Adaptive Histogram Equalization (CLAHE) technique to enhance CT scan images [9]. The CLAHE algorithm partitions the images into contextual regions and applies the histogram equalization to each one. This evens out the distribution of used grey values and thus makes hidden features of the image more visible.

B. Feature Extraction:

After Pre-Processing Curvelet transform is applied to the Pre-Processed Image .From the Curvelet transform Curvelet Coefficients are obtained by Following Steps

The complete process of feature extraction follows these steps [7].

1) Both image and curvelet filter bank are transformed into Fourier domain.
2) Then the convolution of the curvelet with the image in spatial domain becomes the product in Fourier domain.
3) Finally to compute the curvelet coefficient inverse Fourier transform is applied. But due the frequency response of curvelet is non-rectangular wedge, the wedge must be wrapped into rectangular to perform inverse Fourier transform.
4) By periodic wedge tiling wrapping is done, then collecting the rectangular coefficient area in the center.
5) After that inverse Fourier transform is applied and curvelet coefficients are obtained. The whole process is shown in figure 5.

C. Thresholding:

After getting curvelet coefficients small coefficients values are removed images because lung cancerous cell does not contain any small coefficients. Small coefficients does not contain.

Curved line and tumor in the image is curved so with the help of thresholding small curvelet values below specified range are neglected and remaining coefficients are inverse transformed. From this inverse transformed coefficients image is obtained [10].

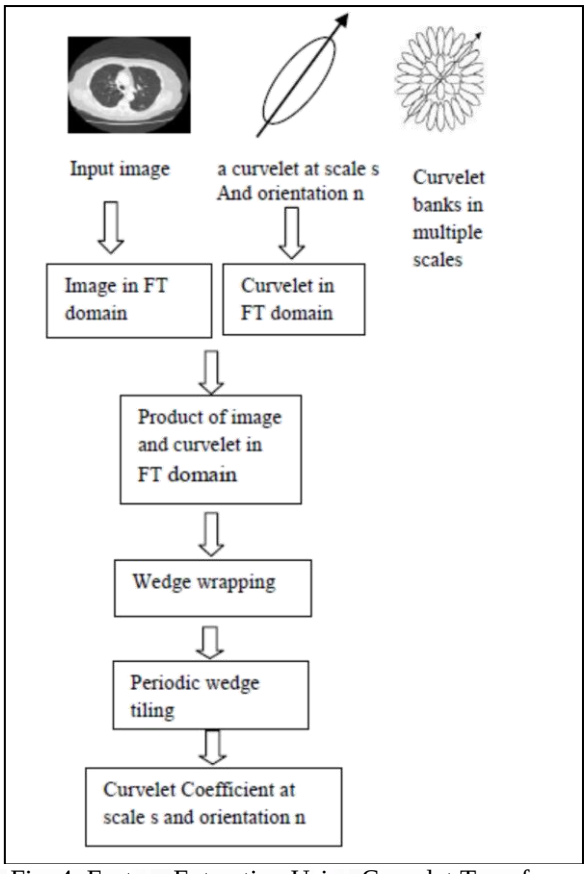


Fig. 4: Feature Extraction Using Curvelet Transform Feature

D. Morphological Operations:

Morphological operations are affecting the form, structure or shape of an object [12]. Applied on binary images (black& white images – Images with only 2 colors: black and white). They are used in pre or post processing (filtering, thinning, and pruning) or for getting a representation or description of the shape of objects/regions (boundaries, skeletons convex hulls).

1) Common Morphological Operations [11]-
2) Shrinking the foreground ("erosion")
3) Expanding the foreground ("dilation")
4) Removing holes in the foreground ("closing")
5) Removing stray foreground pixels in background ("opening")
6) Finding the outline of the foreground
7) Finding the skeleton of the foreground

E. Binarization Approach

Binarization approach has been applied for detection of cancer. In this we extract the number of white pixelsand check them against some threshold to check the normal and abnormal lungs. If the number of the white pixels of a new image is less that the threshold, then it indicates that the image is normal, otherwise, if the number of the white pixels is greater than the threshold, it indicates that the image in abnormal.

F. Image Classification:

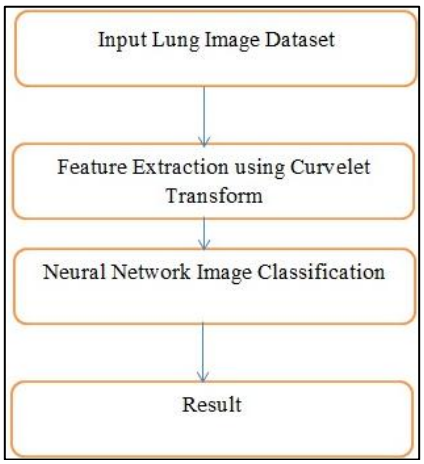


Fig. 5: Image Classification using Neural Network

Image Classification is done by neural Network; First Of all curvelet coefficients are obtained using curvelet transform then following features are extracted Energy, variance, standard deviation entropy out of this features only two features are used for classification .Both features are explained below.

1) Mean and Standard Deviation:

Mean and standard deviation is calculated by following equations

$$\mu_{a\theta} = \frac{E(a,\theta)}{M \times N},$$

$$\sigma_{a\theta} = \frac{\sqrt{\sum_x \sum_y (|Curvelet_{a\theta}(x,y)| - \mu_{a\theta})^2}}{M \times N}.$$

Where, MXN is the Size of the image in row and columnandE(a,θ) is the energy of the curvelet transformed image at scale a and orientation θ.

Based on curvelet coefficients csv coma separated file is generated thiscsv file is considers as a input to the neural network for the Training Phase.

G. Training:

Extracted Features of the Data set are used to train the neural network in the training Phase Positive samples of the lung image which are cancerous are trained by 1 and negative samples of the lung cancer which are non-cancerous are treated as a 0.so this neural network gives output 1 when lung sample is cancerous and 0 when the it is non-cancerous. For the training and testing feed forward neural Network is used.

H. Classification:

When the test images are applied to the neural network after training phase, neural network classify that the image is cancerous or not in the testing phase.

I. Results:

In this proposed method total 95 images are taken from the database for the training and 45 images are taken for the testing in which out of the 95 images 55 images are cancerous which are train by 1 and 40 images are treated as a non-cancerous which are trained as a 0.

The Performance of the classification of the network is evaluated by Specificity,sensitivity and Accuracy

Equation of the Respective parameters for classification is as shown below.

SE = TP/(TP+FN)*100 (4)

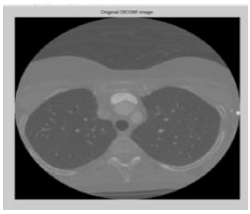
SN = TN/(TN+FP)*100 (5)

AC = (TP+TN)/(TP+TN+FP+FN)*100 (6)

Where TP –True Positive FN –False Negative
TN –True Negative FP – False Positive
TP: Predicts cancerous as cancerous.
TN: Predicts noncancerous as noncancerous
FN: Predicts cancerous as noncancerous.
FP: Predicts noncancerous as cancerous.

VI. EXPERIMENTAL RESULTS

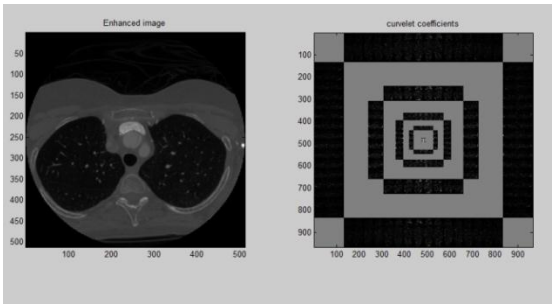
In Figure 6 Different Results are shown for image Segmentation.



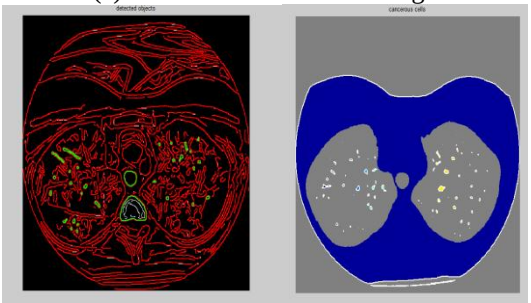
(a)

(b)

(a) Original DICOM Image (b) Enhanced Image



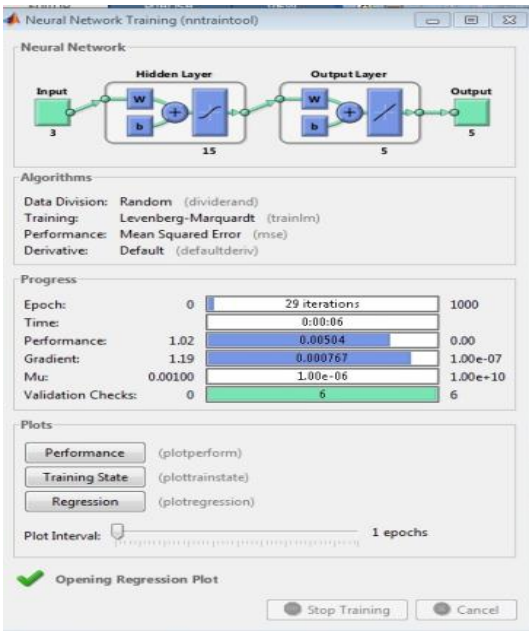
(c) Curvelet Transformed image



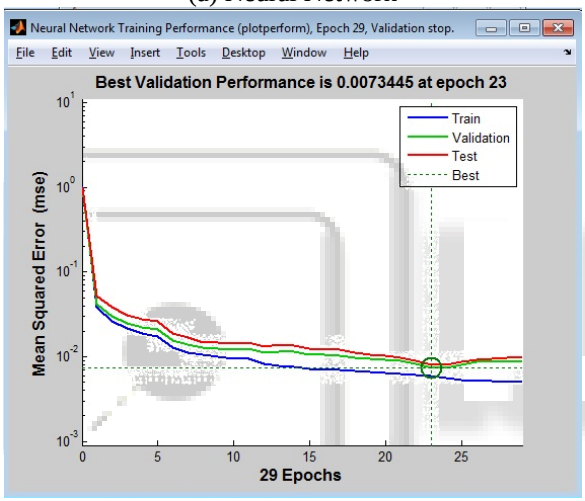
(e) Detected Objects (f) Segmented Image

Fig. 6:

Results of Neural Network are shown in Figure 7.



(a) Neural Network



(b)Performance Parameter

Fig. 7:

A. Results after Testing Network

Research Method	No of Images	Sensitivity	Specificity	accuracy
KNN	28	81.00	83.00	89.00
ANN	50	82.00	90.00	90.00
SVM	60	84.00	92.00	87.00
Proposed	95	87.00	93.55	91.00

Table 1: Simulation Results

VII. CONCLUSION

Lung Cancer is the most dangerous diseases so detection of the diseases at earlier stage helps to save life of a patient. From the literature Review many techniques are exists with some limitations. In our Proposed method Curvelet transform successfully detect the cancerous cells in lung cancer and Proposed Network contains 91% accuracy compare to other networks .if the cancerous Cells are detected at the early stage then life of patient can be saved which improve the survival ratio.

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