EXTRACTION AND ANALYSIS OF SARCOIDOSIS ILD PATTERN FROM LUNG CT IMAGE

ABSTRACT

Morphological changes are often associated with unwanted growth of tissues. Identifying and quantifying these changes have always used as first line of diagnosis. Most of the clinicians expressed cumbersome due to enormous amount of medical images and also poor quality of images during acquisition, limiting the correct diagnosis. Large range of lung patterns of disease can be observed from CT scan images. For clinical practices, images are accumulated and stored in digital representation from MRI, CT, Ultrasound etc., in PACS, processing and thereby for diagnosis. Medical image segmentation is an important step form resuccessive image analysis tasks. The goal of lung segmentation is to separate region of interest (ROI) for extracting lung abnormalities of Interstitial Lung Disease (ILD) patterns like Sarcoidosis, Idiopathic pulmonary fibrosis, Malignant nodules, and Sarcoidosis structures. These ROI's are affected by background regions and exhibit various levels of quality and brightness. In this project morphology-based segmentation is used to extract sarcoidosis patterns that are used for diagnosis and prognosis of pulmonary disease. The performance of the proposed method is evaluated in noisy environment. Salt and pepper noise, Speckle noise, Poisson noise, Gaussian noise are added to original image for the evaluation of noise effect. Comparison is implemented between patterns from noisy and noiseless images. Noise reduction capabilities of proposed method on a particular noise type is validated based on correlation co-efficient and peak Signal-to-Noiseratio. In this project a GUI is designed to perform Morphology based segmentation to extract Sarcoidosis pattern.

KEYWORDS

CT, CAT, PET, US, ILD, IPF, HRCT, DICOM, Lung, Morphology, Sarcoidosis

INTRODUCTION

The area of medical imaging has developed into a significant scientific discipline. The examination of patient data is gained by image modalities such as CT, MRT, PET, and US. Those imaging methods propose unachieved advancements for diagnosis and therapy evaluation. Medical image processing is necessary to influence increasing aggregation of scientific information and to examine information for specific medical objective. Medical image analysis needs image processing techniques and pre-processing functions like noise removal, image enhancement and edge detection. Feature extraction is executed to acknowledge the ROI which may be tumor, lesion or abnormality. For suspicious connected parts in the image, abnormal colors and appearance are to be physically differentiated by radiologists for advanced observations. For further processing of medical imaging, particular methods to full fill image segmentation are sorted with separate assortative biomedical application. The main intention of medical image processing is to provide valued representation of the contents. Computed Tomography is more likely known as computed axial tomography or CAT scan is a principle that assists X rays (radiographs) and computers (for computations) to generate three-dimensional likeliness of the human body. Other than methods using photographic films that signify opaque physical organs like bones, CT stipulates thorough range of the contrast tissues, such as lymph's, muscle tissue for fluid pumping and body parts like lungs. CT images render a physical representation which assists in identifying distinct pneumonic diseases like ILD and also tumors. Several pulmonic diseases can be determined by studying the lung tissue patterns of pulmonary CT images. So, segmentation of lung is a primitive operation to acquire texture extraction and analysis. ILDsaremorethan200different types which are heterogeneous group of parenchymal lung disorders due to alveolar septal thickening, fibroblast proliferation, collagen decomposition and pulmonary fibrosis. Majority of ILDs are due to unknown causes Known causes may be inhaling organic or inorganic dusts, gases, fumes, drugs, radiation and smoking infections. ILDs are classified into acute, chronic and episodic. Acute ILDs are because of infection, allergy or toxins. Chronic ILDs are caused by drug side effects and most common are cancer, IPF sarcoidosis and honey combing. A pulmonary lung nodule is any space occupying lesion either solitary or multiple on the lung that is 3cm in diameter or less and if larger considered as Lung mass, are cancerous. Malignancy of lung nodules in elder people seems to be more cancerous and serious issue for mortality.

LITERATURE REVIEW

Morphological and anatomy-based techniques classify insignificant three-dimensional mass in the lung using size, brightness, and region of interest (ROI). Xiaolei and Gavrii's “Biomedical Image Processing” consigned their theories to establish and accomplish decoct significant features comprising image dimensions, appearance, and irregularities in medical images. Rastgarpour and

Shanbehzadeh's “Biological and Medical Physics, Biomedical Engineering” and “Digital Imaging and Communications in Medicine (DICOM) - A Practical Introduction and Survival Guide” ascertained peculiar methods for segmenting truthful image features. These techniques used to divide the image rely on many constraints like the mass of the disease and distinguishing the structure of the image. These results provoke a difficult task for the researchers to project on literature dealing with image segmentation. Edge detection is one of the most commonly used operations in image analysis. An edge is defined by a discontinuity in grey level values. In other words, edge is the boundary between an object and the background. The shape of the edges in images depends on many parameters: the geometrical and optical properties of the object, the illumination conditions, and the noise level in the image. Detection applied to Medical images is an important work for object recognition of most of the human organs such as lungs, brain and ribs, and it is an essential pre-processing step in segmentation of medical image and analysis. The edge detection process decides the result of final processed image. In real world applications, a medical image acquired contain important features like object boundaries and object shadows and sometimes noise. The processing to be applied depends on the content which one desires to extract. Therefore, a frequent problem in low-level vision arises to eliminate and suppress the noise and other unrelated detail from the degraded image, without degrading the regions of interest. Felix Ritter, Tobias Boskamp, André Homeyer, Hendrik Laue, Michael Schwier, Florian Link, and Heinz-Otto Peitgen performed Medical Image Analysis where, the lesions in the lung are been identified with the various ILD patterns Sarcoidosis, Honey Comb Pattern. The major intention behind this thesis is to overcome the faulty assumptions made by radiologists. These can happen with the chance of his low eyesight vision or it may be a chance of holding and seeing the CT image under dim light vision. Kushal Kr. Roy and Amit Phadikar both of them have implemented a tool Automated Medical Image Segmentation where the HRCT image can be processed into a software tool to detect the lesions without any intervention from humans. V.Vijaya Kishore, R V S. Satyanarayana both of them designed a Computer-Aided Diagnosis Tool for Honey Comb Detection by using Morphological and Wavelet Transform in Lung CT Images. Here, the image is scanned by the software, and later, the image is segmented with the help of the WaterShed algorithm, which is best practice in use for fast computation later, the Lung CT image is been detected with the ROI after, the application to the regional boundary conditions for the detections of both possible and annotated abnormalities. Ian D. Robertson, Travis Several, “Hospital, Radiology, And Picture Archiving And Communication Systems” developed a cancer detection method based on image enhancement technique.

PROPOSED METHOD

The Original CT Image is to be loaded from the LIDC (Lung Image Database Consortium). Where this image is been segmented. The segmentation of an image is a major priority for any image analysis and investigation assignments. The identification of the Sarcoidosis ILD pattern is to detect the lesions in the Lung CT image. Thus, the process of finding abnormalities needs a grey level image after the segmentation of the original image and the region of interest is being operated on the Lung CT image thus, the image is been filled with holes to detect the abnormalities based on the threshold value. Note, that the researchers said that for the Lung CT image the minimum sarcoidosis level of the pattern is 5mm whereas, for HRCT images the minimum sarcoidosis level of the pattern is 10mm. Based, on that assumption the image with the minimum size has been concluded and thus, the operation of finding abnormalities are been detected. This project is modeled with morphology-based reconstruction to segment the lung as ROI and ILD pattern sarcoidosis. The Original Image is segmented using the Watershed algorithm and processed further to evaluate the Original Region of Interest (ROI). The Original ROI is further processed to the image filling and then the image is been identified with the sarcoidosis pattern for the Original ROI image. The evaluation of both possible abnormalities and annotated abnormalities is based on the threshold value. The project is implemented by designing and developing a CAD-GUI tool that can help clinicians in the decision-making of diagnosis and prognosis.

The basic mathematical morphological operators are dilation and erosion and the other morphological operations are the synthesization of the two basic operations. In the following, some basic mathematical morphological operators of gray-scale images are introduced. Let $F(x, y)$ denote a gray-scale two-dimensional image, and B denotes a structuring element. Dilation of a gray-scale image $F(x, y)$ by a gray-scale structuring element $B(s, t)$ denoted by $(F\oplus B)(x,y) = \max\{F(x-s,y-t) + B(s,t)\}$

Erosion of a gray-scale image $F(x, y)$ by a gray-scale structuring element $B(s, t)$ is denoted by $(F \Theta B)(x, y) = \min\{F(x + s, y +t) - B(s,t)\}$

Dilation is the maximum pixels set union when the structuring element overrides the image, while erosion is the minimum pixels set union when the image is overlapped by the structuring element. Opening and closing of gray-scale image $F(x, y)$ by gray-scale structuring element $B(s, t)$ are denoted respectively by

$F \circ B = (F\Theta B) \oplus B$

$F \bullet B = (F\oplus B) \Theta B$

Opening operation is the dual closing operation, i.e., opening the foreground pixels in an image with a particular structuring element is equivalent to closing the background pixels with the same element in the same image. Similarly, closing

operation is the dual opening operation, i.e., closing the foreground pixels in an image with a particular structuring element, is equivalent to closing the background with the same element.
Erosion is a transformation of shrinking, which decreases the gray-scale value of the image, while dilation is a transformation of expanding, which increases the gray-scale value of the image. But both of them are sensitive to the image edge whose gray-scale value changes obviously. Erosion filters the inner image while dilation filters the outer image.

Opening erosion is followed by dilation and closing is dilation followed by erosion. Opening generally smoothes the contour of an image and breaks narrow gaps. As opposed to opening, closing tends to fuse narrow breaks, eliminate small holes, and fill gaps in the contours. Therefore, the morphological operation is used to detect the image edge, and at the same time, denoise the image.
Among all morphological operators, the opening and closing operators are fundamental. They can be used for image description as well as image manipulation (with noise filtering as a special case). Given their sensibility to noise, in recent literature, several proposals were published to improve their robustness. The majority aim to improve their performance as a filter.
Morphological edge detection algorithms usually select an appropriate structuring element to process an image by making use of the basic morphological theory that includes operations such as erosion, dilation, opening and closing, and synthesization operations to get a clear edge image. In the process, the synthesized modes of the operations and the feature of the structuring element decide the result of the process image. In detail, the synthesized model of the operations reflects the relation between the processed image and the original image, and the selection of the structuring element decides the effect and precision, and the result. Therefore, the keys of morphological operations can be generalized for the design of morphological filter structure and the selection of structuring elements. In medical image edge detection, it is needed to select appropriate structuring elements by the texture features of the image. And the size, shape, and direction of the structuring element must be considered roundly. Usually, except for special demands, select the structuring element by3×3square.
The operation features of morphology, erosion and dilation operations satisfy:
$F \Theta B \subseteq F \subseteq F \oplus B$
Opening and closing operations satisfy:
$F \circ B \subseteq F \subseteq F \bullet B$
What is discussed above shows that dilation and closing operations can expand the processed image while erosion and opening operations can shrink the processed image. But the processed image is similar to the original image.

METHODOLOGY

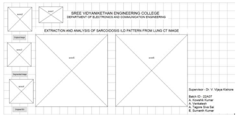
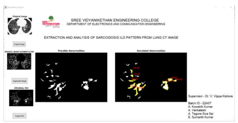
Steps to follow the extractoin of abnormalities:

1. Creating a Graphical User Interface (GUI) layout design in MATLAB
2. Collecting the DICOM Lung CT images.
3. Develop gradient images using appropriate edge detection function.
4. Mark the Foreground Objects using morphological operation.
5. Compute Background Markers.
6. Compute the Watershed Transform of the Segmentation Function.
7. Extraction of lung region.
    a. Use Structuring Elements (Square, Disk) to probe an image with a small shape or template.
    b. Perform Morphological operations like - opening by reconstruction.
    c. Perform closing by reconstruction.
    d. Compliment the input image.
    e. Reconstruction is performed to extract the original image.
8. Display of Sarcoidosis ILD patterns-ROI that includes lung region.
9. Any discontinuities present are filled, so that perfect region properties like boundaries and their respective centroids are maintained which helps to evaluate the area of the abnormality accurately
10. Taking the area as a parameter to detect the abnormalities, all the possible abnormalities are annotated with areas. This quantification can be taken as secondary opinion to understand the progress of the Sarcoidosis ILD pattern. Based on this the diagnosis and prognosis of the disease can be performed.

GUIDE

MATLAB Graphical User Interface development environment provides a set of tools for creating graphical user interfaces (GUIs). These tools greatly simplify the process of designing and building GUIs. GUIDE automatically generates an M-file that controls how the GUI operates.

DIFFERENT FUNCTIONAL TOOLS DEVELOPED AND INTEGRATED INTO THE MATLAB GUI TOOL

Tool bar Menu	Functions performed by the individual fields	
GUI Interface	Open MATLAB GUI Interface. Insert static text, axes, push buttons in the MATLAB GUI. Save the GUI workspace. Run the GUI workspace.	
Load Original Image	View the GUI in the MATLAB Interface. Load the image of different formats (tiff, jpg, png, bmp, DICOM, etc,). Load the Original DICOM image. Save the Original DICOM image.	
Segment the Original Image	Load the Segmented Image which is extracted from Original DICOM Image from GUI. View the Segmented Image in MATLAB GUI Interface. Save the Segmented Image in workspace.	
Process the Original ROI Image	Load the Original ROI Image which is extracted from Segmented Image from GUI. View the Original ROI Image in MATLAB GUI Interface. Save the Original ROI Image.	
Sarcoidosis Pattern	The proposed GUI system for automatic detection and quantification of lung Sarcoidosis ILD pattern from DICOM-CT scan image uses this method. After segmenting the ROI and its directional details, the tool further extracts the lesion details (sarcoidosis patterns) and measures the roundness by applying a predefined threshold to the ROI. It measures the lesion details and roundness	
Quantification of Abnormalities	Here, both possible and annotated abnormalities are viewed. These plots are used to estimate the efficiency of the proposed research work in extracting the ROI, and identification of sarcoidosis on watershed based analysis	

RESULTS AND DISCUSSIONS

Medical image segmentation is an important step for most successive image analysis tasks. In automatic detection of lung nodules, the goal of the lung segmentation is required to separate the regions corresponding to the lungs. CT is considered to be the most accurate imaging modality for early detection and diagnosis of lung cancer. Manipulation of volumetric CT data sets may improve a radiologist's ability to detect small nodules. With the integration of computers in medicine, a need arises to develop computer assisted tools for the optimized detection and quantitative evaluation of the largest number of small nodules identified by volumetric chest CT in both diagnosis and screening studies. A method is proposed that performs extraction of the lung region for nodule detection based on morphological operations watershed, and wavelet transforms. This method can be used as a tool for automatic detection of lung nodules from DICOM-CT scan image. The steps of the method are described in detail next.

Lung Extraction

The goal of the lung extraction is to separate the voxels corresponding to lung tissue from the voxels corresponding to the surrounding anatomical structures. Watershed transform is a region-based approach. Generally, on the gradient image the watershed transform is applied, where the boundaries of the catchment basins are located at high gradient points. A well-known drawback in watershed segmentation is over-segmentation. Since, every regional minimum, even if tiny and insignificant, forms its own catchment basin, over-segmentation occurs. By using marker-based watershed transform, we can decrease the regional minima and bound them within the region of interest to prevent over-segmentation. There are several techniques to define markers and choosing a technique is highly dependent on the application. Before the watershed transform is applied, the gradient image must be obtained first. The Sobel masking operator is applied on the original pulmonary CT image in both horizontal and vertical directions to create the gradient image. The lung region is marked as internal and external markers. The internal markers are the connected components of the pixels with almost the same intensity values, whose external boundary pixel values are all greater than n. The value of n is a gray level value, which specifies the approximate gray level value for non-body pixels in CT images. Since, in pulmonary CT images the air will appear with a mean intensity of approximately -1000 Hounsfield Units (HU), lung region will be in the range of -1000 to -400 HU and the chest wall, blood and bone will be much dense and well above -400 HU. In order to specify the internal markers, the regions with pixel values lower than -400HU are selected.

Background Removal

The background of the CT image is almost black (lower than -400HU), so, it makes an erroneous regional minimum. There is a high degree of similarity between the gray levels of Lungs and the image background. So is removed bye liminating the objects, which are attached to the border of the binary image. After eliminating the background, the small objects in the markers which are caused by theveins should be eliminated. The close morphological operator is used to obtain the compliment to eliminate the small objects and a complete internal marker is obtained.

External Marker

Lung border is located in the neighborhood area of the internal marker. To bind this area an external marker is required. The internal marker is dilated with two circular structuring elements with different ratios.

Regional Minima Impose

Regional minima will be placed only in the marked area of the gradient image. This is required to compute the waters headlines in the region of interest. Minima imposition procedure, which utilizes morphological reconstruction, is used to place regional minima only within the area of the union of the two markers.

Watershed Transform

Watershed transform of the obtained image finds the watershed lines corresponding to the most significant edges between the markers. These watershed lines are the borders of the lung regions Since during this transform a dam is created between the two lung regions to prevent merging, the thin wall between the attached left and right lung is also extracted.

Filling and Lung Extraction

In some CT images, the segmented lung region excludes dense structures, such as juxta pleural nodules and hilar vessels. To include these structures the rolling bar filter is used. The segmented lung border is superimposed on the original image and the closed morphological operator is applied.

Wavelet Transform

In the proposed approach, discrete wavelet transform is used to decompose the segmented image into directional sub-images. Discrete wavelets correspond multiresolution approximations of the images. Biorthogonal wavelets are used to obtain the intensity approximation, horizontal, vertical, and diagonal directions.

The discrete wavelet transform of image f(x,y) of size M and N can be written as

$$W_{\Phi}(j_0, m, n) = \frac{1}{\sqrt{MN}} \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} f(x, y) \Phi_{j_0, m, n}(x, y$$

$$W_{\Psi}^{i}(j, m, n) = \frac{1}{\sqrt{MN}} \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} f(x, y) \Psi_{j, m, n}^{i}(x, y)$$

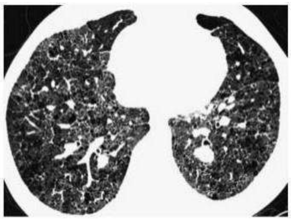
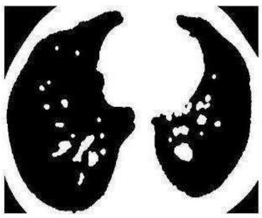
$$i = \{H, V, D\}$$

$\Phi_{j_0,m,n}(x, y)$ and $\Psi^{i}_{j,m,n}(x, y)$ are the scaled and translated basis functions:

$$\begin{aligned} \Phi_{j,m,n}(x, y) &= 2^{\frac{j}{2}} \Phi(2^j x - m, 2^j y - n) \\ \Psi^{i}_{j,m,n}(x, y) &= 2^{\frac{j}{2}} \Psi^{i}(2^j x - m, 2^j y - n) \\ i &= \{H, V, D\} \end{aligned}$$

Φ(*x,y*) is the scaling function and Ψ*H*(*x,y*), Ψ*V*(*x,y*), and Ψ*D*(*x,y*) are three two-dimensional wavelets, which are the products of one-dimensional Φ and corresponding wavelet Ψ. is a superscript that identifies the directional wavelets.

The methodology is implemented on the DICOM lung CT image. This image is given as input and the corresponding ILD patterns, directional details and extracted lesions are obtained. Segmented ROI and the directional details of sarcoidosis pattern. The final lesion details of sarcoidosis pattern extracted from the lung ROI.

		
Original lung CT image	*Gradient of image*	*Image open*

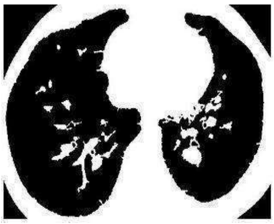
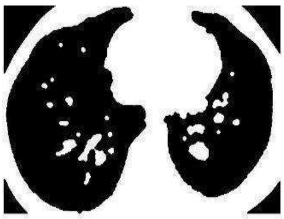
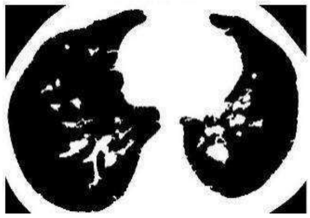

		

Image reconstruct	*LOC*	*Image compliment*

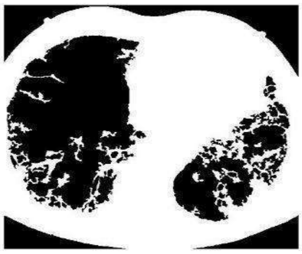
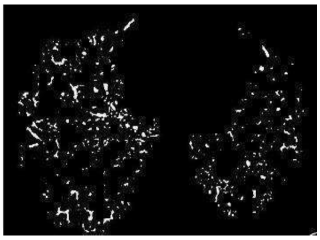
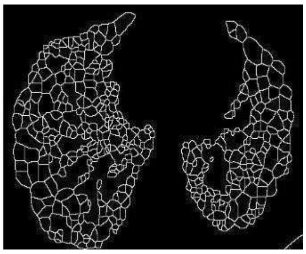
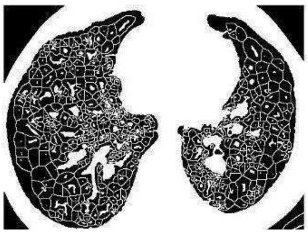
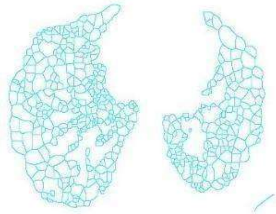
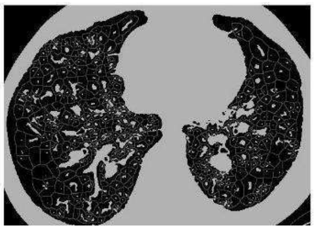
		
Foreground Image	*Foreground superimposed*	*Background image*
		
Markers and boundaries super imposed on image	*Lrgb*	*Lrgb superimposed transparently on original image*

Fig.7.1: Resultant intermediate images of Sarcoidosis pattern extraction

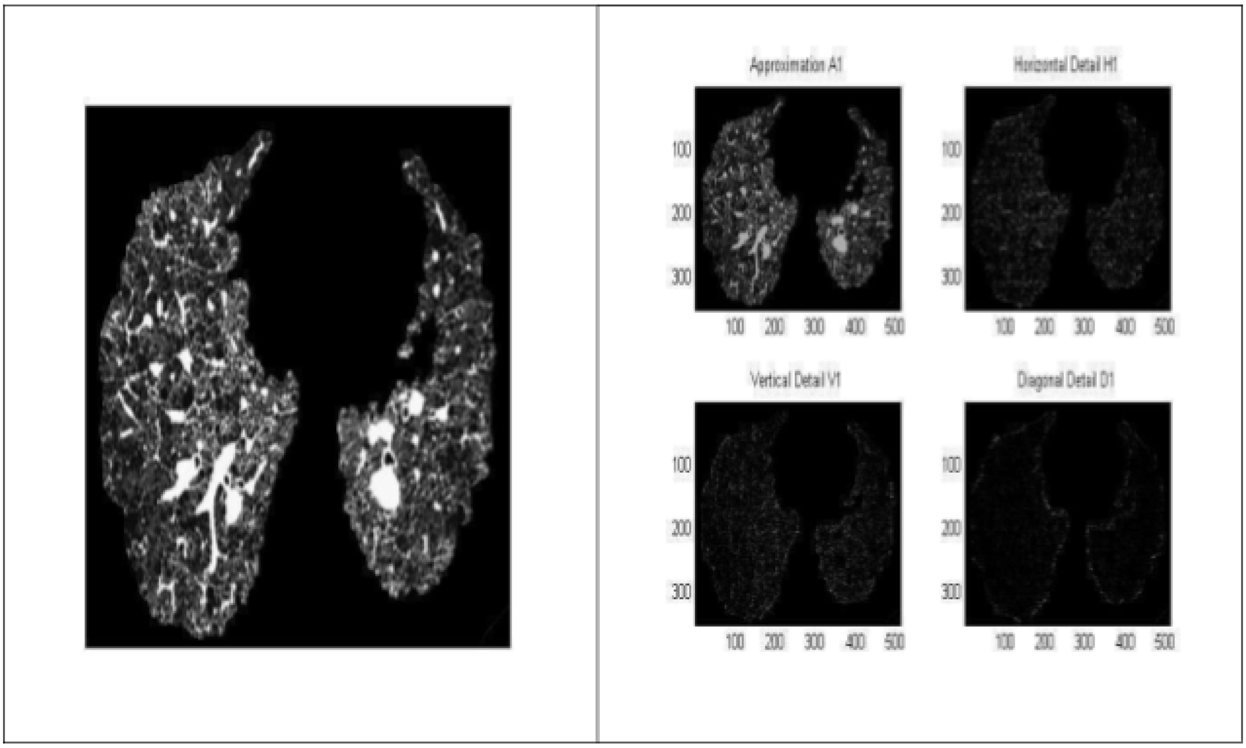


Fig.7.2: Segmented ROI and directional details of Sarcoidosis Pattern

Fig.7.3: lesion details (sarcoidosis pattern detected by ROI) of Sarcoidosis Pattern

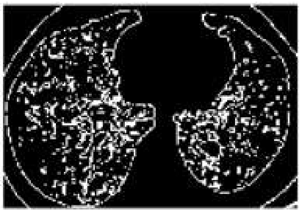
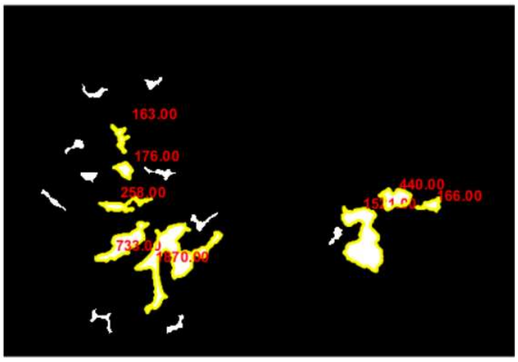
	
Original Image Segmentation	*Original ROI*
	
Possible Abnormalities	*Annotated Abnormalities*

Fig.7.4: Resultant Images

CONCLUSION

Majority of the pulmonary diseases and their identification rely on geometric progression of lung spaces. Some of the physicians expressed the inadequacy in image parts which are known as (ROI)Region Of Interest. Researchers conver seat focusing on ROI coding to guarantee the use of multiple and randomly shaped ROI's in image, because depicting the importance of ROI is affected by the background regions that exhibit various levels of quality, brightness, and shapes. In this project, a GUI is designed to perform morphology-based segmentation is used to extract Sarcoidosis ILD pattern is developed and implemented. Morphology based region of interest segmentation is implemented to extract various lung patterns by lung ROI segmentation that delineates the diseased part. The results provide a high-quality visual screening of extracted patterns of different ILD patterns such as malignant nodules, and sarcoidosis pattern. The resulting images provide valuable information about the structures and their growth over a duration of examination which helps the clinicians for early diagnosis and prognosis. In addition to this, the proposed method is evaluated in the presence of noise to estimate the noise reducing capability of the method for a particular noise. The peak signal to noise ratio and correlation coefficient are computed for extracted Sarcoidosis patterns from original and noise added images. It is observed that the proposed method has reduced the effect of Poisson noise compared to Salt and pepper noise, Speckle noise, and Gaussian noise. This is identified by high values of PSNR and Correlation Co- efficient for Poisson noise compared to other noise.

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