GUI Tool for Detection and Analysis of Honeycomb ILD pattern from Lung CT Images

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Abstract

In recent years we have seen a tremendous growth in Computer Aided Diagnosis (CAD). A multifunctional GUI tool is designed, that can be accepted universally to diagnose and analyze the growth of the disease. The goal of proposed work is to build a GUI - CAD tool that extract Honeycomb pattern from lung CT images, calculate the noise impact in doing so.And also annotates all possible abnormalities and areas are mentioned beside the extracted honeycomb patterns showing the progress of the disease. The honeycomb pattern extraction from ROI is done through applying morphological operations, reducing complexity and making it suitable for the real-time applications. This is considered as a secondary opinion by clinician for further treatment that is to be carried out.

Keywords—CAD, CT, Lung, Honeycomb, ILD, Morphology, ROI, Segmentation.

I. INTRODUCTION

The vicinity of clinical imaging has evolved right into a large medical discipline. CT, MRT, PET, and US are some image modalities used to examine patient data. Those imaging techniques endorse unachieved improvements for analysis and treatment evaluation. In order to research data for a specific clinical purpose and convince the rising collection of clinical information, medical image processing is essential. Image processing methods including pre-processing tasks such as noise reduction, image enhancement, and edge detection are required for medical image analysis. The ROI, which might be a tumour, lesion, or anomaly, is identified via feature extraction. Radiologists must physically separate abnormal coloration and appearances in suspicious related portions of the image for improved observations. Different assortative biomedical applications are sorted to fulfil certain image segmentation requirements for subsequent processing of medical imaging. Medical image processing's major goal is to give a valuable depiction of contents. Computed Tomography, CAT scanning, also known as computed axial tomography, is a technique for creating 3D scans of the humanusing X–rays (radiographs) and computers. The CT scan allows for a full range of contrast tissues, including muscle tissue, lymph, muscle tissue, and bodily organs like the lungs, in contrast to methods employing photographic films that represent opaque organs like bones.

Refinement of medical representations controls complex accessions to enhance rough pathological inputs for reliable determination, with considerable emphasis on relevant applications and theory[1, 2]. The use of segmentation, registration, and visualisation in computer analysis increases diagnostic acuity and confidence[3, 4]. Pathological patterns, when subjected to a certain set of activities in order to achieve a specific goal, will modify supplementing collections of unbiased reports and regard them as a result of the demand of explicit medicinal data[5]. Image processing performance approaches and techniques to suppress inappropriate distortions for feature enhancement that are related to noise reduction, representation intensification, and contour discovery are used to test, dissolve, and analyse problematic patterns. The quality of the counterparts is extracted to support the range of importance, which may be lump, abrasion, or aberrancy[6]. ILD and sarcoma are two significant lung pathologies that CT scans can identify. CT models, in which lung segmentation promote the nature and pattern of the image along with its investigation, the apparent bronchi motif may be clearly investigated[3]. A spot-permeating abrasion in the pleura known as a nodule will be 3 cm across the module or maybe even less. When a lesion spreads beyond its original size, it is seen as a tumour and unmistakably referred to as cancer[7]. Identification and acknowledgment of these groups as serious risks to the connective tissues of the alveolus [8].

Inconsistent attitude characteristics, such as a hoop, that occur at contour edges in inflammations that grow like tumours or nodules [9] are acquired by these growths. Finding a simple test to find the level of bioluminescence and related specks is the fundamental strategy. The antecedent practise is acquired via conception, drafting, and transformation strategies [10].The third system uses a concoction component to combine the information to obtain allocation. The demarcation approach is used in a persuasive process to choose the appropriate restorative representation[11]. A model is distinguished by the technical inspection and analytical procedures that separate the prototype motif from its characteristics. If the basic approach of the model is investigated, the ROI of its object actualization characteristics is calculated[12]. The use of neighbourhood expansion, discontinuity, and closure procedures is used to include quantity or frequency measuring approaches.Linguistic and diagnostic techniques separate infinitesimal 3D contusions in the alveolus by assessing their size, lustre, and scope of concern[13].

CT scans provide a physical depiction that aids in the identification of certain pneumonic abnormalities such as ILD and malignancies. The lung tissue patterns on pulmonary CT scans can be used to diagnose a variety of pulmonic disorders. So, the basic process in lung segmentation is to extract textures and analyse them. ILDs are a broad group of parenchymal lung illnesses brought on by pulmonary fibrosis, fibroblast proliferation, alveolar septal thickness, and collagen breakdown [3]. There are about 200 distinct forms of ILDs. Most of the ILDs are caused by unknown factors. Breathing synthetic or natural dusts, gases, pollutants, medicines, radiation, and smoking diseases are all known causes. ILDs are grouped into three categories: acute, chronic, and episodic. Infection, allergies, or toxins cause acute ILDs. Extrinsic Allergic Alveolitis or pulmonary eosinophilia cause intermittent ILDs. The three chronic ILDs that are most frequently brought on by drug side effects are cancer, IPF sarcoidosis, and honeycombing [5]. A pulmonary lung nodule will be any solitary or numerous space-occupying lesion on the lung that is 3meters in diameter or less, and is called a lung mass if it is greater.

Honey combing is a CT picture of widespread pulmonary fibrosis. The grouped cystic air spaces, which are mainly sub pleural and basal in pattern, are 3-10millimeters in diameter but can infrequently be about 2.5centimetres [3]. It is difficult to detect honeycomb patterns because of its appearance, that changes as the disease progress in the lungs of the patient.

We review and contrast approaches that were developed to detect the honeycombing pattern based on structure and texture. [14] exhibited a wide-ranging architecture for CAD that performs observation on the lung nodules in CT images. This architecture has the diagnostic components with capabilities integrated such as: automated detection of nodule, its tracking and measuring the volume. [15] evaluated CAD influence inspects execution in recognizing early lung disease on chest radiographs. [16] depicted CAD segmentation based on marker-controlled watershed procedures to find possible masses of tumor in the breast.

II. SEGMENTATION

The first and most important stage in image analysis is segmentation. The goal of the segmentation process is to divide a picture into discrete, semantically meaningful items by identifying borders between features and objects in the image based on some constraint, such as homogeneity. The ability to effectively divide a picture into discrete, non-overlapping parts is indeed the segmentation. The sort of problem being solved influences the level to which this segmentation is carried out. Once the application's item of interest has been separated, the segmentation procedure is complete. The construction of related areas that record the whole image region, or the determination of the image's boundary or borders, is the outcome of separating an image from its backdrop. These segmentations transform the image into a form that makes it simple and meaningful to examine. A method for identifying objects and edges in a picture is called image segmentation. Each pixel in a given area of an image is given a label using image segmentation algorithms, ensuring that pixels with same labels have comparable visual characteristics. The result of the segmentation process is either a collection of segments that together make up the full image or a collection of edges or outlines that are extracted from the image. Each pixel in a region bears some similarity to any distinguishing characteristic or calculated attribute, such as colour, intensity, or texture, but neighbouring regions have remarkably different characteristics.

The majority of segmentation algorithms are based on one of two gray level value qualities, namely either Discontinuity or Similarity. The image is portioned using the discontinuity property, which is based on rapid changes in gray level. This technique is often used to find edges and lines in a picture as well as isolated points. Thresholding, region growing, region splitting, and merging are the main approaches in second category. Relevant segmentation determines the precision and evaluating certainty in identifying any lung issue. Image segmentation is a technique for describing image boundaries or objects. The visual characteristics of images with comparable objects belonging to same intensity as a group are achieved by medical image segmentation.

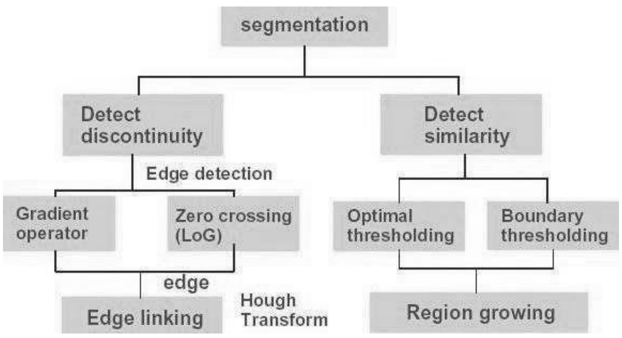

Fig. 1: Categories of segmentation

A. EDGE BASED SEGMENTATION

Edge based segmentation algorithms identify the edges by using the first and second derivatives producing outlines which borders the segments. The derivatives are obtained by the application of different masks to the image. The mask is a small non-matrix proposed by Sobel, Laplace, Kirsch, Prewitt and various others. Each of these masks has their own output characteristics. The kind and nature of the input picture play a vital role in mask selection. The tools for integration of segmentation, extraction and classification of images can be developed. Hospital Information System (HIS) and Picture Archiving and Communication Systems (PACS) using digital entities to keep medical investigations, images and reports [17].

Recognizing malignant nodules from the lung image is a crucial task as the image may contain noise during the processing that can be unnoticed because they have similar intensities of and tissue thickening [18]. Segmenting of low contrast images is a critical part of medical image processing. Early detection of abnormalities is critical for enhancing treatment options and boosting the overall survival percentage of patients [19]. The Edge-based segmentation techniques are capable of detecting fine edges in the image, but they typically enhance noise in the image. Edge based segmentation techniques require a huge processing power, which is about 'n' times the image size for each mask of nan, but it always requires a finite amount of time. On the other hand, image clustering, a technique of region- based segmentation for certain type of images sometimes does not terminate.

B. REGION BASED SEGMENTATION

Region based segmentation algorithms work by grouping similar valued neighbouring pixels of image. Several techniques that fall under this category include thresholding (that include local, global and adaptive), clustering, region growing, region merging and splitting. Thresholding is implemented by grouping intensity values of the pixels by a set of predefined criterion values as borders. Intensity values of the pixels that lie between the border values according to the predefined criteria are assigned the same intensity value, thus combining into the same region or segment [20]. Clustering algorithms work by randomly selecting a certain number of pixels as seed points called starting points, and then grouping other pixels that have intensity values near specified by a predetermined tolerance level at the starting points.

III. MORPHOLOGICAL OPERATIONS

Mathematical morphology can be used for processing and analysing the images. Image features that are important in the presentation and interpretation of region are extracted using morphological techniques. Morphological operations [20] are a set of fundamental activities that are reliant on the shape of the picture. It's usually performed with binary images. It requires two data sources, one of which is the input picture and the other of which is the structuring component. Morphology of models characterise imprecisely determined processes that akin toward profile, aspect and presence of the representation [1]. This concept has sufficient view on conformation of models [21]. The perception on ROI by CT imaging technique is possible from structural characteristics. Counterparts are extracted for primary diagnosis by selecting the operative elements structure and size [22].

Morphological operators use two inputs: an image and a structural component, which are then combined using set operators. The elements in the input image are processed based on the structuring component's encoded properties of the image's shape. Opening is comparable to erosion in that it removes bright foreground pixels from the edges of foreground pixels areas. The operator's effect is to protect foreground pixels that are identical to the structuring component, or that may completely enclose the structuring component while removing all other foreground pixels. An image's internal noise is removed using the opening operation. Opening is opposite of closing, i.e., picture's foreground pixels are opened with a particular structural element is equivalent to using the same element to close image's background pixels. Similar to how opening is the opposite of closing, i.e., picture's foreground pixels are closed with a given structural element is equivalent to using the same element to close the background pixels. Erosion is a shrinking transformation that lowers the image's gray-scale value, whereas dilation is an expanding transformation that raises the image's gray-scale value. However, both of them are susceptible to the image edge, which has a noticeable shift in gray-scale value. The inner picture is filtered by erosion, while the outside image is filtered by dilation. Erosion is followed by dilatation during the opening process, and dilation is followed by erosion during the closure process. In general, opening smoothens the contour of an image and fills in small gaps. Closing, rather than opening, has the effect of fusing narrow breaks, eliminating tiny holes, and filling gaps in the outlines. As a result, morphological operations are employed to identify image edges while also denoising the image. Opening and closing operators are the most fundamental morphological operators. They may be used to describe images as well as manipulate them (with noise filtering as a special case). Given their sensitivity to noise, various approaches to increase their robustness have been reported in recent literature. The majority of people want to increase their filtering performance.

Usually, morphological edge detection algorithms use the best structural component to analyse an image and by using basic morphological operations and synthetization one can extract a clear edge image. The outcome of the processed image is affected by the synthesised modes of operations and the structuring element’s features used during the process. In further detail, the processed image's relation to the origin image is reflected in the synthesized mode of operations, and the effect, precision, and outcome are determined by the structuring element chosen. As a result, the keys to morphological operations may be used to create morphological filter structures and choose structuring elements. The textural properties of the image are used to pick appropriate structuring elements in medical image edge detection. In addition, the size, form, and orientation of the structuring element must all be taken into account. Unless there is a unique necessity, choose a structuring element by 3 x 3 square.

Erosion and dilation operations satisfy the following morphological characteristics:

$$F \Theta B \subseteq F \subseteq F \oplus B \tag{1}$$

Closing and opening operations satisfy the following morphological characteristics:

$$F \circ B \subseteq F \subseteq F \bullet B \tag{2}$$

What was previously mentioned demonstrates that erosion and opening operations can cause the processed picture to shrink, while dilation and closing procedures can expand it. However, the altered image resembles the original image. In order to extract the region of interest while it is inflicted to conduct something for achieving a conclusion when the data is synthetically prone to noise in order it should not confuse the investigation and determinations. Counterparts are lay over with cacophonies to choose the ability of offbeat operators at the restoration process [10]. Watershed method highly are good to extract the ROI as it follows ridges absolutely to identify and separate the backgrounds and clear noise details [12]. Wavelet transforms are used for scaling the signal which are random in nature [23].

IV. THE PROPOSED SCHEMES

In this section, we will get into proposed schemes with a detailed explanation in steps.

Step 1: Collecting the DICOM Lung CT images.

Step 2: Convert the CT image into gray image.

Step 3: Appropriate edge detection functions are used to evaluate the gradient magnitude of DICOM image.

Step 4: Perform morphological operation to mark the Foreground objects.

Step 5: Background Markers are computed.

Step 6: Watershed Transform is applied.

Step 7: ROI are extracted.

Step 8: Display of ILD patterns-ROI that includes lung region and Honey Comb pattern.

Step 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.

Step 10: Taking the area as a parameter to detect the abnormalities, all the possible abnormalities are annotated with areas. These quantifications can be taken as secondary opinion to understand the progress of the Honey Comb ILD pattern. Based on this the diagnosis and prognosis of the disease can be performed.

V. RESULTS AND DISCUSSION

The evaluation parameters are evaluated using appropriate formulas and the values are noted in the below table. The methodology is implemented on the lung CT images. A GUI is designed and developed for the purpose is shown in Figure.3. The proposed method has the capability of segmenting the image for extracting the honeycomb patterns, directional details. The GUI is tool which will help the clinicians by providing the lesion details along with the area quantification for the possible abnormalities that are extracted and detected. The results provide a high-quality visual screening of extracted honeycomb patterns and information about the structures and their growth over a duration can be notified.

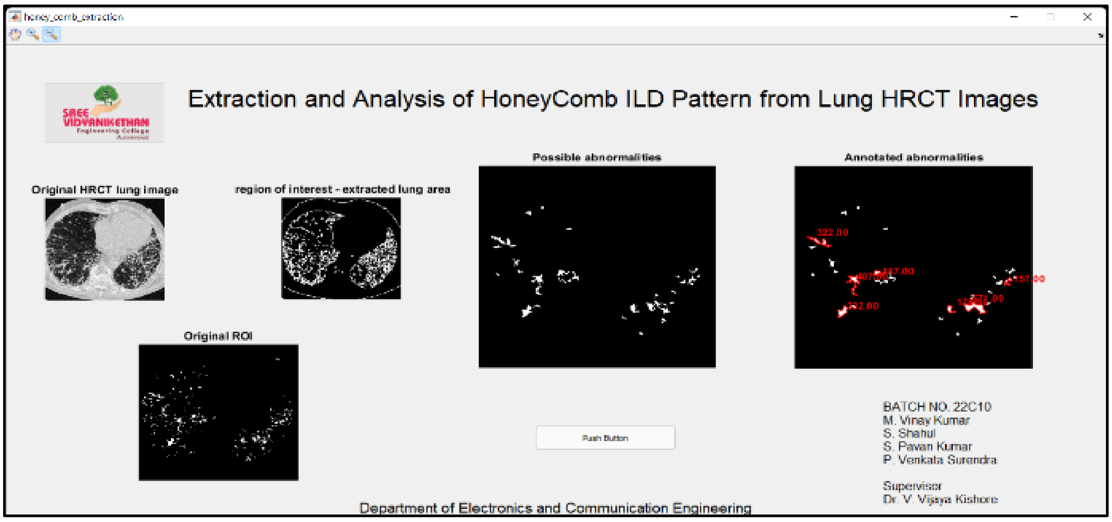

Figure 3. Annotated abnormalities

VII.CONCLUSION AND FUTURE WORK

The majority of pulmonary disorders and their diagnosis are based on the geometric evolution of lung spaces. Some clinicians stated their dissatisfaction with image regions known as Region of Interest. Because depicting the relevance of ROI is impacted by background regions that show varied degrees of quality, intensity, and forms, researchers are concentrating on region of interest coding to ensure the usage of numerous and ROIs of random shapes in images. In this project, a GUI is being designed and implemented to do morphology-based segmentation in order to extract the Honeycomb ILD pattern. Morphology-based ROI segmentation has been used to extract diverse lung patterns. The findings give a crystal-clear view of extracted patterns from various ILD patterns, such as malignant nodules and honeycomb patterns. The resultant images give useful information more about structures and their development throughout the course of the tests performed, which aids physicians in early diagnosis and prognosis.

Future work might include assessing the abnormalities, their progression, and descriptive features. Furthermore, the algorithm can be improved to examine the obtained patterns by altering the structural components for morphology-based ROI segmentation as well as for different ILD patterns, resulting in an algorithm that is trustworthy in the case of DICOM images that have noise.

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