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AUTOMATIC LUNG NODULE SEGMENTATION FOR MEDICAL DIAGNOSIS

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Abstract- *Lungs segmentation is a vital step for computer aided diagnosis. Many lungs diseases requiring radiological support for diagnostic purpose, including tuberculosis, emphysema and lungs cancer could be effectively diagnosed using computer-aid. Pulmonary nodules usually act as the early stage characterization of lung cancer. It's a crucial way to control the disease and reduce the mortality by further examination on the diagnosis of pulmonary nodules. But the large number of the image data and lesion analysis make difficulties to radiology expert for the correctness and effectiveness. So the computer aided detection for the pulmonary nodules turns out to be the hot subject of medical image processing. In this paper, we follow the classic step in detecting the nodules and an effective algorithm based on the morphology and spatial relationship to search the lesion. This method provides an extremely effective way to locate the nodules.*

Keywords*: pulmonary nodule; computer-aided detection; CT image; morphology; spatial.*

I. INTRODUCTION

Lung cancer is one of the leading causes of death in Asian countries. Surgery, radiation therapy, and chemotherapy are used in the treatment of lung carcinoma. Computerized Tomography (CT) is considered to be the most accurate imaging modality available for early detection and diagnosis of lung cancer. It allows detecting pathological deposits as small as 1mm in diameter. These deposits are called lung nodules. Lung cancer has possessed the maximum rate of cancer death around the world, if the patients could be treated at the early stage of lung cancer, they could have more chance to survive or be longevity. Pulmonary nodules are the characterization of the early stage of the lung cancer [1]. Computerized Tomography (CT) which is widely used in the lung disease check could be the most useful tool to detect the nodules. Several studies demonstrated that 90% of peripheral lung cancers were visible in CT images earlier than the date of the cancer discovery by the radiologist. Image processing and visualization techniques for volumetric CT data sets may improve the radiologist's ability to detect small lung nodules. For example, reconstruction of CT images with narrow inters scan spacing and interpretation of images using cine rather than film-based viewing technique, have been reported to improve small nodule detection. Computer-assisted tools to improve the detection of small nodules from chest CT are needed and are being actively developed. A solitary pulmonary nodule is a small, round or egg-shaped lesion in the lungs. Pulmonary nodule is a small, worm-shaped lesion connected to pleura. Nodules are typically asymptomatic, and they are usually noticed by chance on a chest X-ray that has been done for another reason [2][3]. They are usually smaller than 3–4 cm in diameter (no larger than 6 cm) and are always surrounded by normal, functioning lung tissue. Their intensity in CT scans is from -300 to 0 HU Nodules are fairly common abnormalities on chest X-ray images: nearly one of every 500 chest X-rays shows a newly diagnosed nodules. Pulmonary nodules may be primary lung cancer tumors or metastases from other parts of the body. If the lesion is suspected to be benign, serial chest X-rays or CT scans may be taken on a regular basis for observation of the lesion. If the affected person is at high risk for lung cancer or if the CT scan appearance of the lesion suggests it is pulmonary, surgical removal of the lesion is recommended.

II LITERATURE SURVEY

The development of medical images acquisition techniques, in particular computerized tomography (CT), which may furnish more detailed information about the human body, has increased the capability and fidelity in the diagnosing of many diseases. On the other hand, the dimensions of these images are becoming bigger and bigger, increasing the need for computer vision techniques that can make interpretation easier. This Section aims to provide an overview of literature in automatic CT image analysis in the lung region. The work of Beigelman-Aubry et al. [2] presented evaluation of nodule detection and its response time when performed by radiologists with and without use of a computerized system. The work showed that the system improves the sensibility of the detection, what raised the trust interval in 2%. Among the experiments with 109 patients, there was a nodule which was not detected by one of the radiologists, but was detected by the system. Besides, the use of the system decreases considerably the time required by the specialists to analyze the exams. This way, nodule detection systems, have great importance in this process, despite they do not give the final diagnosis. Nodule detection systems usually involve four steps: preprocessing, extraction of nodule candidates, reduction of false positives and classification. Pre-processing normally consists in restricting the search space, delimiting the lung, and reducing noises in the image. The region of the lung is segmented and nodule candidate objects are identified. Among these objects most of the non-nodule are discarded in the false positive reduction stage. The remaining objects are then classified into nodule and non-nodule. In some methods, the false positive reduction is performed after classification. Some works found in the literature involving these steps are presented next.

Armato and Sensakovic [3] showed the importance of adequate segmentation of lungs in computer aided detection and/or diagnosing systems. His studies indicated that up to 17% of lung nodules can be lost during lung segmentation if the algorithm is not adjusted to the task of nodule detection. A great challenge is the segmentation of lungs affected by high density pathologies connected to their bounds. Due to the lack of contrast between these pathologies and the tissues adjacent to the lung, density-based methods fail in this region. In this case, it is necessary some edition technique, but, even so, part of the lung is normally lost [4].

Due to the large amount of air in the lung, its interior has dark tonality in CT images, differing from the region around it. This way, contrast between lung and neighbor tissues is the basis for most lung segmentation methods. Most methods is based on rules [5]. The lung region can be found by two ways . The first one is by means of region growing starting at trachea. The second one, more usual, used thresholdings and restrictions in size and location.

To find nodule candidates, the main techniques used are multiple thresholding, mathematical morphology, clustering, analysis of connected elements in threshold images, detection of circles in threshold images and use of emphasis filter with spherical structure elements. In Osman et al. [7], for each slice, regions of interest (ROI) were found by using the density values of the pixels and analyzing their eight directions. The joining of all slices formed 3D ROIs, which compared to a model template (template) allows identifying the nodules. Sensibility reached 100%, but the test data were restricted to six cases.

III. METHODOLOGY

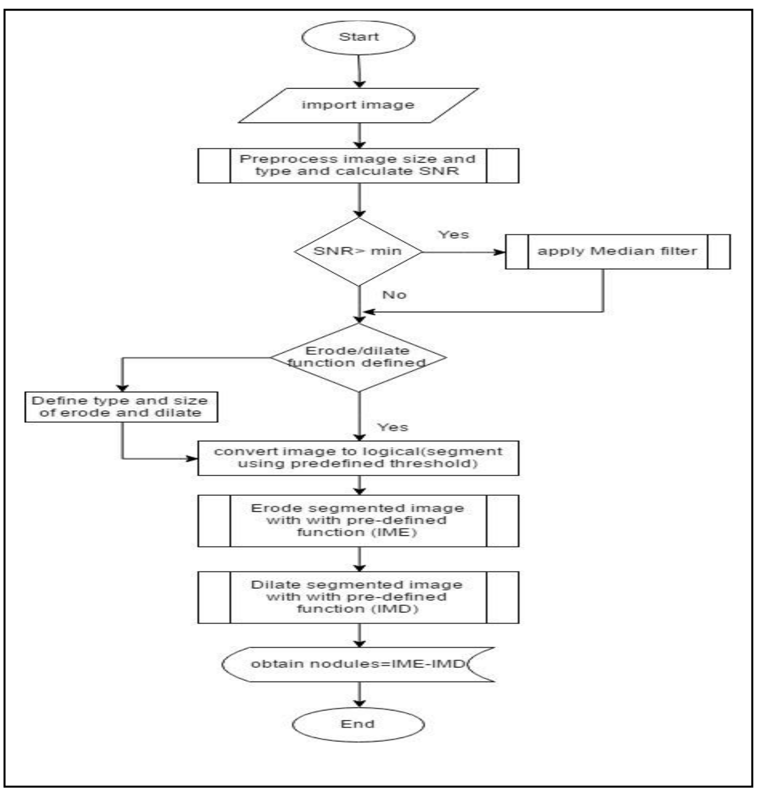

Fig.3.1: methodology

3.1 **CT scan images**

HIGH-RESOLUTION X-ray computed tomography (CT) is the standard for pulmonary imaging. Depending on the scanner hardware, CT can provide high spatial and high temporal resolution, excellent contrast resolution for the pulmonary structures and surrounding anatomy, and the ability to gather a complete three-dimensional (3-D) volume of the human lung in a single breath hold.

3.2 Gray scale images

Grayscale images also known as black and white are composed exclusively of shades of gray, varying from black at the weakest intensity to white at the strongest. It contains values from 0 to 255 (it allows 256 different intensities i.e., shades of gray).

3.3 Pre-processing process

Fast and satisfied medical CT segmentation is known to be difficult due to speckle noises and other artificial effects. Speckle is the inherent property of the CT image itself. In areas of image visualization and automatic-segmentation, speckle is considered a contamination factor. Reducing the speckle noise for segmentation becomes important which also improves image visualization to a great extent. Since CT scan images contained contamination factor such as speckle noise reducing speckles in the image was important, for which some pre-processing steps were also performed to enhance image visualization for segmentation. Different enhancement techniques were followed to remove speckle noise for better image post processing (segmentation). Enhancement was done to reduce noise and blurring and increasing the contrast range could enhance the image [8]. The original image might have areas of very high and very low intensity, which mask details. Radiologists use this technology to manipulate CAT scans, ultra scans and MRI images. Some of the enhancement techniques are: brightness or contrast gamma correction, despeckle, erode, dilate, blur, sharpen, soften, edge enhance, add border, etc.

3.4 Median Filter

Median filter it is often desirable to be able to perform some kind of noise reduction on an image. The median filter is a nonlinear digital filtering technique, often used to remove noise. Such noise reduction is a typical pre-processing step to improve the results of later processing (for example, edge detection on an image). Median filtering is very widely used in digital image processing because under certain conditions, it preserves edges while removing noise. Since it is particularly effective in removing speckle noise and salt and pepper noise it was implemented as one of the pre-processing techniques on CT images. If there is an even number of values, the median is the mean of the middle two [9]. A median filter is an example of a non-linear spatial filter using a 3X3 mask; the output value is the median of the values in the mask.

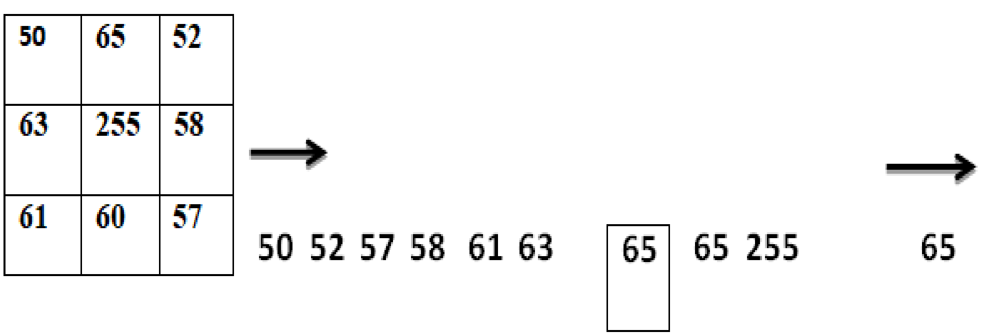

Fig.3.2: Example for Median Filter

We see that very large or very small values (noisy values) will end up at the top or bottom of the sorted list. Thus the median will in general replace a noisy value with one closer to its surroundings.

3.5 Segmentation process

Segmentation is done in order to separate the region of interest from the background. Image segmentation has found wide applications in the field of medical and biomedical imaging. Some of these methods can be broadly classified as:

clustering, edge detection, model based, thresholding, neural networks and other artificial intelligence based techniques. CT scan image segmentation is strongly influenced by the quality of data. There are characteristic artifacts, speckle noise and unrelated region. Further complications arise as the contrast between areas of interest is often low. Henceforth the image had to be segmented effectively for better diagnosis.

3.6. Adaptive Thresholding

Thresholding enables the separation of the image under consideration into two separate classes (i.e., the region or object of interest and the background) using a specified threshold. Adaptive thresholding is an automatic segmentation technique which is a local technique (i.e. it resolves the intensity levels within a particular area of the image) used in the project. This algorithm is based on the image information (pixels) being processed. It can cause very low intensity areas to become white and very high intensity areas to become black based on the amount of texture with that area. Using the global threshold values it can be specified that really dark or really white areas are always dark or light respectively [10]. This helps to reduce the noise caused by the local analysis of textured light or dark areas. To be effective for CT scan, adaptive algorithm was used as it could recognize the difference between real targets and artifacts. To modify its processing accordingly – it adapted automatically to the nature of the target, ideally both locally (i.e. within an individual image) and temporally (over time from image to image), reducing artifacts while preserving diagnostic information. The running average of the image was computed.

The integral image in the first pass through the input image was calculated. In the second pass, the average of the image was computed. If the value of the current pixel was t percent less than the average then it was set to black, otherwise it was set to white.

3.7 Dilation

Dilation is a process where the set or object is expanded from its original shape. The way, the object is expanded is determined by the structuring element. This structuring element is smaller in size compared to the object itself and normally the size used for the structuring element is 3 x 3. The way the process is done is similar to the convolution process, i.e. the structuring element is reflected and shifted from left to right and from top to bottom. At each shift, the process will look for any overlapping similar pixels between the structuring element and that of the object. If there exists an overlapping, then the pixels under the center position of the structuring element will be turned off i.e. 0. Mathematically, this process is written as follows:

$$A \oplus B = \{Z \mid (\hat{B})_Z \cap A \neq \emptyset\} \quad \textbf{(3.1)}$$

Eq.3.1 states that when set *A* is dilated by the structuring element *B*, the outcome element *z* would be that there will be at least one element in *B* that intersects with an element in *A*. If this is the case, the position where the structuring element is being centered at in the image will be on. This is how an object will be enlarged or dilated. This process is illustrated in Figure 3. All colour squares (either blue or red) represent 1 and white squares represent 0. Red and blue colours are used just to differentiate between the structuring element *B* and object *A*.

1. Dilation process increases the gray scale value of the image by applying expanding transformation.
2. Dilation filters the outer image.
3. The dilation operations will expand the processed image

The dilation is the one of the two basic operators in mathematical morphology. The basic effect of dilation on binary images is to enlarge the areas of foreground pixels (*i.e.* white pixels) at their borders. The areas of foreground pixels thus grow in size, while the background "holes" within them shrink.

Again let us take a 3x3 matrix for the structuring element, with the center pixel used as the origin of the set. *B*, then the dilation can be performed using the logical OR function:

1. If the pixel is set to foreground, it remains such.
2. If the pixel is set to background, but at least one of its eight neighbors is set to foreground, the pixel is converted to foreground.

3. If the pixel is set to background and none of its eight neighbors is set to foreground, the pixel remains set to background.

Explanation using example

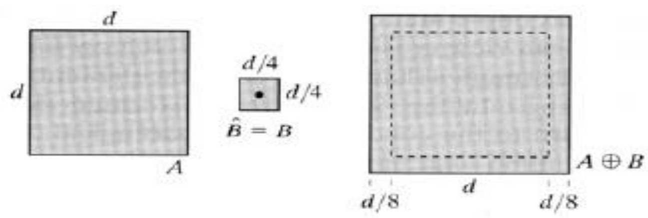

Fig.3.3: First example for dilation illustration

In fig. 3.3**,** Set B is commonly referred to as the structuring element, and also viewed as a convolution mask. Although dilation is based on set operations where convolution is based on arithmetic operations, the basic idea is analogous. B is flipping about its origin and slides over set (image) A. Set *A,* structuring element *B,* and dilation of *A* by *B.* Boundary of set *A* is shown by the dotted border. Since the SE is symmetric about its origin, *B*ˆ =*B.*

3.7 Erosion

Erosion is the counter process for dilation. If dilation enlarges the object, erosion on the other hand shrinks the object. The way the object is shrunk is determined by the structuring element. The structuring element is also normally smaller than the object itself with 3 x 3 is the most common one. This will ensure that the faster computation time compared to larger structuring element size. Almost similar to the dilation process, erosion process will move the structuring element from left to right and top to bottom. At the center position indicated by the center of the structuring element, the process will look for either there is a complete overlap with the structuring element or not. If there is no complete overlapping, then center pixel indicated by the center of the structuring element will be set to off. Using the set theory terminologies, the erosion process can be written as:

$$A \ominus B = \{ Z \mid (B)_Z \; A \} \ldots\ldots\ldots\ldots\ldots\ldots \textbf{(3.2)}$$

The above Eq.3.2 states that the outcome element *z* consists only when the structuring element is a subset or equal to the object *A*. This process is depicted in Figure 6. Again coloured squares denote on (i.e. 1) pixels whereas white squares denote off pixel (i.e. 0). In this figure same structuring element *B* and object *A* as in dilation is being used.

a. Erosion basically decreases the gray-scale value of an image by applying shrinking transformation.
b. Erosion filters the inner image.
c. Erosion operations shrink it.

Mathematically, erosion of set *A* by set *B* is a set of all points *x* such that *B* translated by *x* is still contained in *A*.

Let foreground pixels be represented by logical 1's, and background pixels by logical 0's. As a practical example, we take a 3x3 matrix of logical 1's, with the middle point chosen as the origin of the set is used as the structuring element *B* .

To compute the erosion of a binary input image by this structuring element, we consider each of the foreground pixels in the input image in turn. For each input pixel we superimpose the structuring element on top of the input image so that the origin of the structuring element coincides with the input pixel coordinates.

1. If the input pixel is set to foreground and all its 8 neighbors are also set to foreground, then the pixel remains set to foreground.
2. If the input pixel is set to foreground, but at least one of its 8 neighbors is not, the pixel is set to background.
3. Input pixels set to background remain such.

Gray scale erosion with a flat disk shaped structuring element will generally darken the image. Bright regions surrounded by dark regions shrink in size, and dark regions surrounded by bright regions grow in size. Small bright spots in images will disappear as they are eroded away down to the surrounding intensity value, and small dark spots will become larger spots. The effect is most marked at places in the image where the intensity changes rapidly, and regions of fairly uniform intensity will be left more or less unchanged except at their edges.

The basic effect of erosion operator on a binary image is to erode away the boundaries of foreground pixels (usually the white pixels). Thus areas of foreground pixels shrink in size, and "holes" within those areas become larger.

With the structuring element chosen as above, the effect of this operation is to remove any foreground pixel that is not completely surrounded by other foreground pixels, assuming 8-connectedness. We can also see that this operation can be performed on binary images simply by applying a logical AND function.

Explanation using example

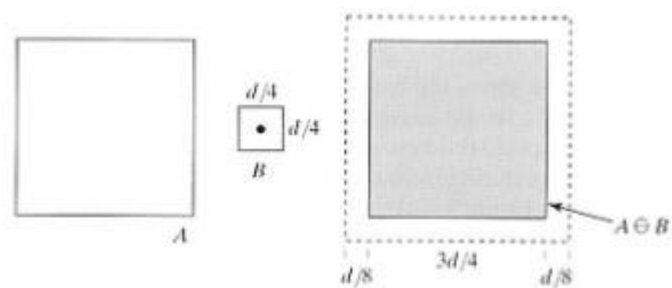

Fig. 3.4: First example for erosion illustration

In fig.3.4 Set *A*, structuring element *B*, and erosion of *A* by *B*. Boundary of set *A* is shown by the dotted border.

IV RESULT DISCUSSION AND CONCLUSION

The graphical user interface of our project is as shown in fig.4.1 and fig.4.2. In our work, we have used .Net framework to develop front end of our project. In our work to detect pulmonary nodules, initially we have taken the CT scan of a patient, which is available from digital libraries at universities. The CT scan is converted into Gray scale image for further processing as shown in fig. Then the preprocessing steps are carried out, which are required for further post-processing. Then the lung ROI and lung outline region is detected using morphological process and finally using spatial characteristics we differentiate the nodules from blood vessels, which may have the similar values as nodules. And finally we get the pulmonary nodules, as shown in fig.4.5 and fig. 4.6 In this work pulmonary nodules have been successfully detected using morphological and spatial methods. And from the survey it is found that the obtained result have shown less false detection of nodules.

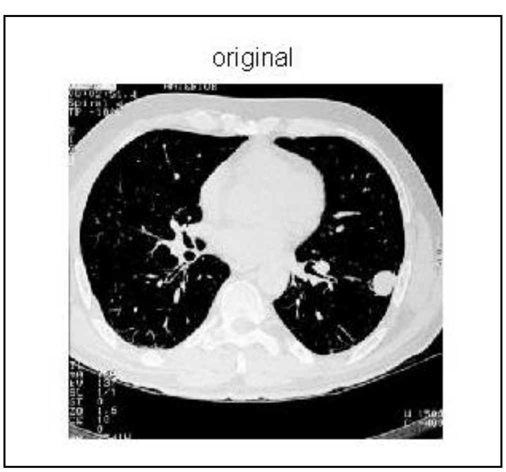

Fig4.1: Original image

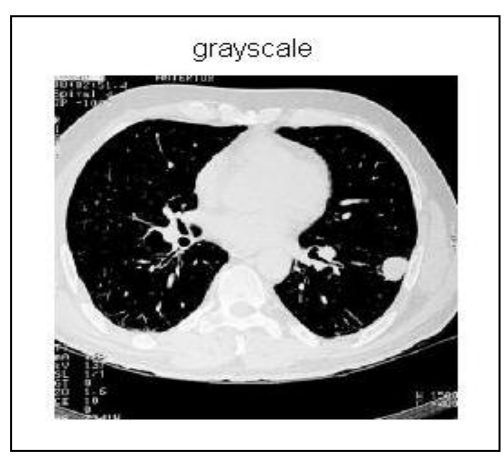

Fig4.2: Grayscale image

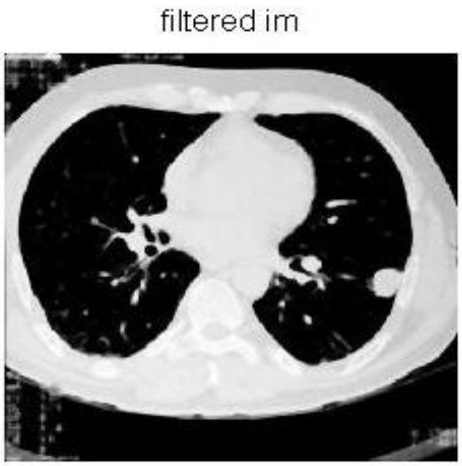

Fig4.3: Filtered image

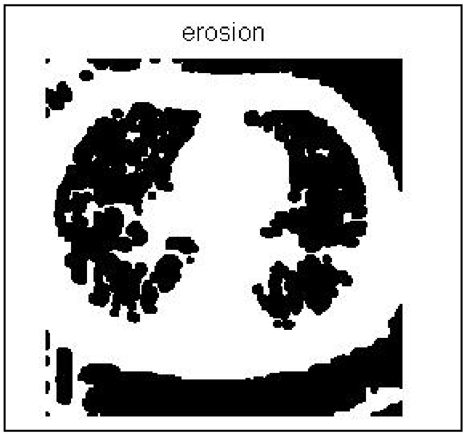

Fig4.4: Erosion

Fig4.5: Dialation

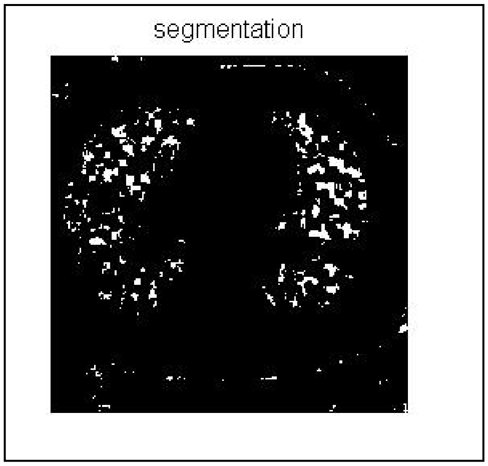

Fig4.6: Segmentation

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