LUNG NODULE SEGMENTATION FOR COMPUTER AIDED 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 I propose an effective algorithm based on the morphology and spatial relationship to search the lesion. This proposal provides an extremely effective way to locate the nodules.

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

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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.

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. 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.

REVIEW OF PREVIOUS PAPERS

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. [1] 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 [2] 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 [3].

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 [4]. The lung region can be found by two ways [3]. 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 thresholded images, detection of circles in thresholded images and use of emphasis filter with spherical structure elements [5].

In Osman et al. [6], for each slice, regions of interest (ROI) were found by using density values of the pixels and analyzing their eight directions. The joining of all slices formed 3D ROIs, which compared to a nodule model (template) allows identifying the nodules. Sensibility reached 100%, but the test data were restricted to six cases.

Retico et al. [7] proposed a system based on emphasis filters for spherical objects and a neural classification based on voxels of selected regions to reduce false positives. The system performance was evaluated in a set of data from 39 CT and reached 80–85% of sensibility and 10–13 FP/exam.

Bae et al. [8] developed a computer aided diagnosis (CADx) for high-resolution CT images (HRCT - high-resolution computed tomography) using bi-dimensional and tri-dimensional analysis algorithms. This technique was tested in eight lung cancer cases and obtained 95% of sensibility and 0.91 FP/slice.

To improve the sensibility of the detection, Li et al. [9] used an emphasis filter in the identification stage and, to reduce false positives, used a rule-bases classifier.

Having the nodule candidate objects been generated, characteristic features of these objects are calculated. Classifiers are then applied. These classifiers use the features to identify candidate objects either into the nodules set or into the non-nodule set.

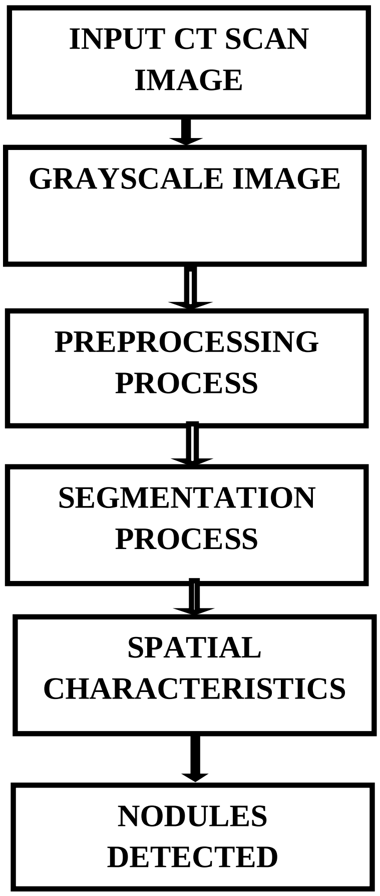
Several techniques can be used as classifiers in the final stage of nodule detection: based on either rules or linear classifiers, by combining models (template matching), analysis of the nearest cluster, support vector machine, neural networks and Bayesian classifier. The features mostly used for classification are features based on the density of voxels, description of shapes, spatial relation and size information.

da Silva Sousa et al. [10] proposed a set of three morphological features specially developed for characterization of lung nodules with which matching rates of 100% were achieved using support vector machine, despite this work used a small database.In some works, the classifier presents good sensibility, but also a high number of false positives. This way, techniques have been looked for, in order to reduce this number after the identification that, in some cases, work as filters before classification.

Armato et al. [11] presented a methodology for the detection of lung nodules with just the pre-processing stages, candidates' detection and classification. Nodule candidates were found by multiple thresholding and, next, using shape and density attributes and discriminant linear analysis, the classification detected 70% of the nodules indicated by specialists and three false positives per slice in average (approximately 80–90 false positives per exam). In some work focus is on rules to reduce the number of false positives: rule-based, discriminant analysis and neural networks.

Lee et al. [12] added the false positive reduction stage to the nodules detection method. To do this, they added five density attributes and adjusted the thresholding parameters to the original model. The sensibility continued the same in 72.4% but the FP rate decreases from 30.8 to 5.5 per exam. False positives reducing is important, because, even if sensibility keeps unaltered, the radiologist's final amount of work is reduced.

METHODOLOGY



System design

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.

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).

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. The original image might have areas of very high and very low intensity, which mask details. Radiologists use this technology to manipulate CAT scans, ultrascans 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.

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.

Spatial characteristics

From the morphological aspect, the pulmonary nodules have a variety of uncertain forms that is due to the different growing environment of the nodules. But it often takes the circle and ellipse as the main state. And the blood vessels usually turn out to be striped or bifurcated. Thus we could separate the most blood vessels from the nodules through detecting the characteristic.

To the aspect of the spatial characteristic, some of the blood vessels that parallel the Z-axis direction perform similarly to the nodules in 2D images. But as the vessels often grow into radial pattern, their line that joins the location of the two adjacent images in the CT image sequence cannot be parallel with the Z-axis direction. On the contrary the nodules will be paralleled. We calculate the offset of the centre of gravity that the suspected lesions in the continuous two images own to describe the feature. If the value of the offset exceeds a certain level, it would more likely to be a blood vessel.

Result Discussion

The graphical user interface of our project is as shown in fig.2 and fig.3. 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.

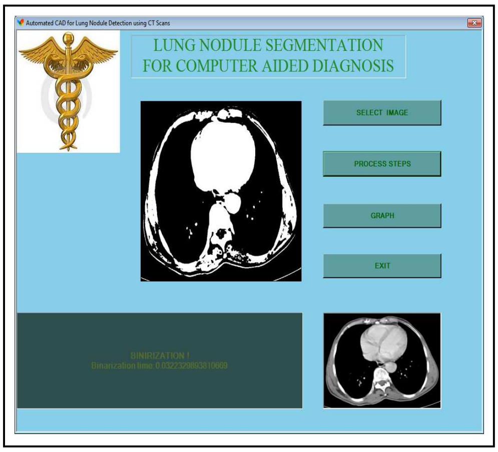


Fig: Gray scale conversion.

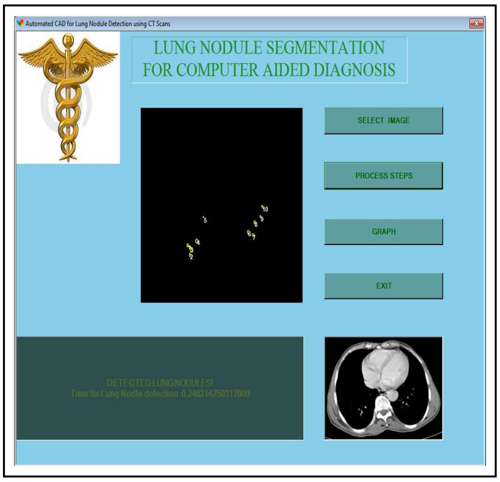


Fig. Nodules detected.

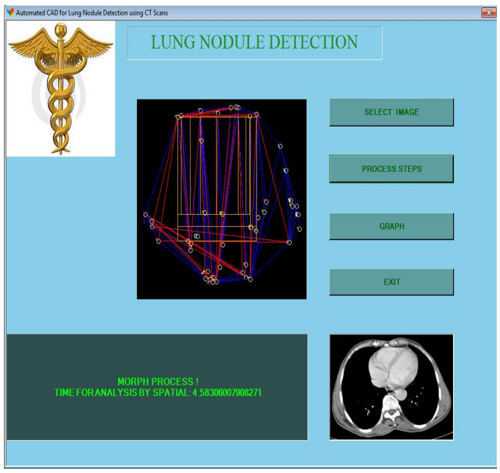


Fig: Spatial characteristics.

CONCLUSION

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.

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