Early Diagnosis of Lung Cancer using Region Growing Technique

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Abstract: **In recent years the image processing mechanisms are widely used in several medical areas to improve earlier detection and treatment stages, in which the time factor is very important to discover the disease among the patient as possible as fast. Lung cancer death rates have been the main cause of cancer deaths in the world, early detection and the treatment of lung cancer can greatly improve the survival rate of patient. Historically more men than women have died from lung cancer as a result of higher level of smoking. So the continuous screening test is required to address this problem. During the past few years, lung cancer detection in magnetic resonance imaging (MRI) has become an emergent research area in the field of medical imaging system. The main objective of this paper is earlier detection of nodule, often small nodule size to be identified to increase the survival rate.**

Index term: MRI, Wiener Filter, Peak -Signal-to-Noise Ratio, Modified Watershed, Morphological Operation.

I. INTRODUCTION

Cancer is one of the most serious health problems in the world. The mortality rate of lung cancer is the highest among all other types of cancer. Lung cancer is one of the most serious cancers in the world, even though survival rate is very less when the diagnosis done too late, so the survival rate is gradually decreased in every year. Survival from lung cancer is directly related to its growth stage and its detection time. The earlier detection will provide, the higher chances to alive in the world. Several researches estimated as 85% of lung cancer cases in males and 75% in females are caused by cigarette smoking. In 2010, 42,026 people in the UK were diagnosed with lung cancer and there were 35,184 deaths from lung cancer. The overall survival rate for all types of cancer is 63%.Although surgery, radiation therapy, and chemotherapy have been used as the treatment of lung cancer, the five year survival rate for all stages combined is only 14%.The main purpose of this paper is to detect the cancer nodule in MRI image, as earlier as possible in order to increase the survival rate. In the past decades several researches are done in the radiograph image as well as in the CT image but both images have some disadvantages.

The difficulties for detecting lung nodules in radiographs are below:

- Nodule size will vary widely.
- Nodule exhibits large variation in density.
- Nodule can appear anywhere in the lung field.

Disadvantage of CT image:

- CT system uses ionizing radiation.
- Contrast material produces some side effects.
- It is a 2D image with less quality in compare with MRI.

To overcome this problem, MRI image is used to detect the cancer nodule. Fig (1) shows the main idea behind the proposed system. It consists of four steps. In the first step MRI images are collected from the LIDC database, in second step that is in pre-processing stage, noise present in the image to be removed using the wiener filter. As in the third step segmentation process is done using modified watershed technique to avoid the over segmentation problem in paper[13].In the final step feature extraction process is done by using several image processing technique such as erosion and dilation process, it mainly depends upon the size and shape of the nodule.

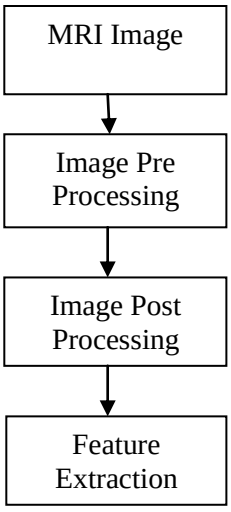

Fig. 1.lung cancer detection system

II. RELATED WORK

During the past decade, combination of spline filter and histogram equalization approach was done on chest radiograph image, to identify the cancerous nodule. It has the following drawbacks like detect the nodule size up to 1 cm and also accuracy was 81.836% [1].some paper mainly concentrated on the camouflaging effect due to ribcage shadow on the lung and reducing the false positive rate per digital chest image[2].The neural network based approach was designed for both chest radiograph [3],as well as for CT image [4].In chest radiograph image[3],author considered the nodule size to be around 8-12mm,so the system gives the better result up to this specified size only, also the classification process is much more complex because of many rule regarding curvature space feature extracted from the nodule. Even though the same approach was designed in CT image [4], it provides the diagnostic accuracy was about 84.6%.Ginneken [5] has classified the lung region extraction into two categories: Rule and pixel based classification and ad hoc rule based rib segmentation. Here the rib was not segmented well [6], this leads to the camouflaging effect and better result was analysed for a particular nodule size. Cancer diagnosis [7] system using least square support vector technique was yields the diagnosis rate up to 90%.Computer aided diagnosis system (CAD) [9],[10] is proposed to detect the cancer nodule, but it is providing the accuracy was averagely around 90%.Normally some CAD [11],system yields the better result for limited amount of database. Watershed algorithm was proposed in some paper to segment the lung region. This algorithm generally suffered with over segmentation problem, it has been eliminated in [12], but the result was purely depends upon the K-means clustering value. Several image processing techniques were design to extract the cancer nodule in CT image. Marker control watershed segmentation [13], with many morphological operations was used to extract the cancer nodule. Mostly this type depends upon the identification of marker, if it is not choose well this leads to the over segmentation problem.

III. PROPOSED WORK

A.MRI

MRI image is used for my proposed work. Magnetic resonance imaging (MRI) is one of the most widely used medical imaging tools in both clinical and research applications. Most clinical MR studies are limited in spatial resolution. For example, the nominal resolution of an MR angiogram is roughly 0.9mm^2/pixel. There are two reasons that higher resolution imaging is uncommon in practice. First, higher resolution requires more data and longer acquisition times. Secondly, given a limited amount of data and/or limited acquisition time, the signal-to-noise ratio (SNR) in high resolution images is quite low. Roughly speaking, we can divide MRI into two type's high resolution with low SNR image and relatively low resolution with high SNR image.MRI is evaluated by the specialist to be more advanced and have better quality of image.MRI can give a 3-D image which can show some of the hidden parts of the body that cannot be scanned in the CT scan method. A better quality image helps the radiologist easier to interpret the result.MRI images are obtained from a NIH/NCI lung image database consortium (LIDC) dataset that provides the chance to do the suggested research.DICOM (Digital Imaging and Communications in Medicine) has become a standard for medical imaging, its purpose is to standardize digital medical imaging and data for easy access and sharing.

B. Image Pre-Processing

It is an initial step for detecting the lung cancer, having two steps:

1. Type of noise
2. Wiener filter

1. Type of Noise

Generally MRI can be classified into two types of image, called high resolution with low SNR image and low resolution with high SNR image. The Lower resolution image have Gaussian noise, it can be eliminated by using wiener filter. Higher resolution image are not used for the practical purpose, it comprised of Rician noise.

2. Wiener filter

The goal of the Wiener filter is to filter out noise that has corrupted in an original image. It is based on a statistical approach. Typical filters are designed for a desired frequency response; however the design of wiener filter takes a different approach. We assumed that the knowledge of the spectral properties of the original signal and the noise to be known, and it can be designed by using linear time-invariant filter whose output would come as close to the original signal as possible. Wiener filters are characterized by the following:

1. Assumption: Signal and (additive) noise are stationary linear stochastic with known spectral characteristics or known autocorrelation and cross-correlation.
2. Requirement: the filter must be physically realizable/causal (this requirement can be dropped, resulting in a non-causal solution).
3. Performance criterion: minimum mean square error (MMSE) is calculated to verify the performance criteria.

The image quality can be proved by calculating the peak signal to noise ratio value. Peak signal-to-noise ratio (PSNR) is the ratio between a signal's maximum power and the power of the signal's noise. Engineers commonly use the PSNR to measure the quality of reconstructed images. Typical values for the PSNR measure for better quality image between 30 to 50 dB, where higher is better. It is most easily defined via the mean squared error (*MSE*), where it denotes the mean square error for two m×n images

*I(i,j)&I (i,j)*where one of the image is considered a noisy approximation of the other and is given by,

$$MSE= 1/mn\ (\Sigma\Sigma\ [I\ (i,j) -K(\ i,j)\ ]^2) \quad (1)$$

$$PSNRdB=10\cdot\log(MAX^2/MSE\ ) \quad (2)$$

C. Image Post processing

Modified Watershed Technique is used to segment the preprocessed image. The following steps to be implemented to segment the image using this technique.

Step1: Gradient magnitude

Basically watershed is applied on the gradient image. The gradient defined the first order partial derivative of an image and contains the measurement for the change of graylevels.The gradient values G(x, y) of the original image can be obtained by using gradient operator. One common application of watershed segmentation is to extract regions or blob-like objects of uniform or near uniform intensity. Since a region with low intensity variation has small gradient, therefore in practice watershed segmentation often applies on gradient images instead of original images. In such cases, high gradient magnitudes are at object or region boundaries, while low gradient magnitudes occur inside regions or objects. The goal of this step is to generate gradient magnitude images that are to be used for later segmentation step. Here two sobel filters, one is horizontal and the other one is vertical filter, are applied on the original image .This process generates two edge images,*Gx and Gy*.These images are then used to calculate gradient image.

$$G(x,y)=\sqrt{Gx^2+Gy^2} \quad . \quad (3)$$

Step 2: Foreground Marker

One reason that leads to over-segmentation, results from a large number of potential but trivial regional minima. The goal of this step is to locate regional minima that are more likely containing nodules.

A regional minima has to satisfy three conditions

1) Surrounded by higher value;
2) Region areas are bigger than a predefined threshold value; and
3) Points inside a region are connected and are of the same intensity value.

In proposed approach, since markers are picked from original images and nodules have higher intensity values than its surroundings, the foreground markers are located at regional minima. The locations of these regional minima are mapped back for segmentation on gradient images in last step. To pick foreground markers, a variety of morphological functions are applied; Opening by reconstruction and Closing by reconstruction. Opening by reconstruction is erosion followed by image morphological reconstruction. This operation is used to remove some of the bright pixels from the edges of regions. Depending on the size of the structure element, this step will also effectively remove some regional maxima. Closing by reconstruction is a dilation followed by image reconstruction. This operation is applied to shrink background colour holes inside the regions. This will actually lead to the merging of regions which also remove trivial regional maxima. Compared with normal opening and closing, opening by reconstruction and closing by reconstruction are less destructive and it can maintain an object's shape better.

Step 3: Background Markers

While the foreground markers determines allowable regions to start the flooding process, the background markers constrain the flooding process so that it will stop at the edges of the objects we are trying to segment. To this end, an adaptive thresholding segmentation method is applied on the original image. After that, with holes inside regions filled and very small regions removed, the segment boundaries are used as background markers in our approach. After this step construct the image with both foreground and background markers overlaid it.

Step 4: Watershed Transform

Watershed Transform is a type of flooding process, in which the flooding sources are the minima of the function. The result of this transform is to partition the image into different catchment basins and watershed lines .Catchment basins are corresponds to homogeneous grey region in the image. Watershed lines are used to separate different catchment basins, to avoid the merging process among the basins. In this step, first the locations of foreground markers and background markers are mapped to the gradient magnitude image and then gradient magnitude to be modified, so that it has only regional minima. Finally, Watershed transform is performed on the modified gradient magnitude image. Morphological operations to be performed in order to extract the cancer nodule.

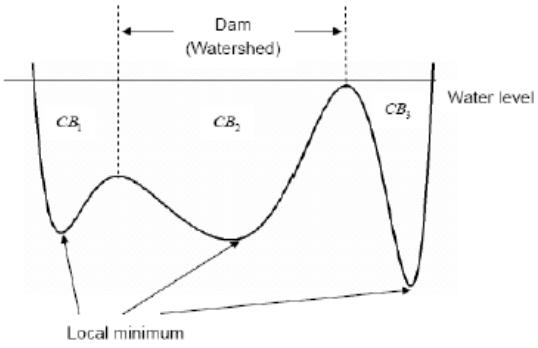

Fig. 2.Basics of Watershed Transform

D. Feature Extraction

Features Extraction stage is very important stage in image processing techniques which using several algorithms and techniques to isolate various desired portions or shapes

(features) of an image. After the segmentation is performed on lung region, the features can be obtained from it and the diagnosis rule can be designed to exactly detect the cancer nodules in the lungs. This diagnosis rules can eliminate the false detection of cancer nodules resulted from segmentation and provides better diagnosis. Normally the cancerous region can be described in many aspects, such as the colour, edge, texture, shape and size of the region. Colour is widely used descriptor because in initial segmentation small regions are varying lot in size and shape, but high similarity in colour. Cancerous areas will normally appear as brighter round shape in the image. So we can use a morphological operation such as erosion and dilation to be performed in order to extract the cancer nodule by distinguish the bright area and the darker areas. In Mat lab, the image is coded as a matrix whose value of the element is the intensity of each point (pixel). Based on this, we can divide the image into many groups of pixels which contains pixels of similar intensities. The small areas (appear to be noise and text) can be deleted and this leaves only the interested cancerous area. In this step, the morphological operations such as dilation and erosion are performed. Corresponding Mat lab code for this operation as follow:

a) Strel': it is used for creating structuring element (se) such as disk shaped, square shaped, ball-shaped, and line-shaped elements.
b) Erosion (imerode) : it is used to shrink or reduce the size of an image according to the shape and size of the structuring element, While preserving the image information.
c) Dilation (imdilate): it is used for dilating or increasing the size of object in an image by filling or expanding an image according the shape and size of the structuring element, by using THIS PROCESS lung nodule to be extracted from the image.

IV. EXPERIMENTAL RESULTS

Lung cancer MRI database are collected from LIDC website. Fig (3) shows the abnormal lung tissue, where the cancer nodule to be present at the left side of lung. Here we use low resolution type of image, depends upon the magnetic field strength image to be classified. If the field strength is 1.5T, and then it is called as low resolution image. Probably, these images are corrupted by Gaussian noise, it can be eliminated using the wiener filter, which is shown in the Fig (4).After that this pre-processed image to be segmented using Modified watershed Technique, Fig(5) shows the marker superimposed on the image. Morphological operations can be implemented in the final step to extract the cancerous nodule, which is shown in the Fig (6).

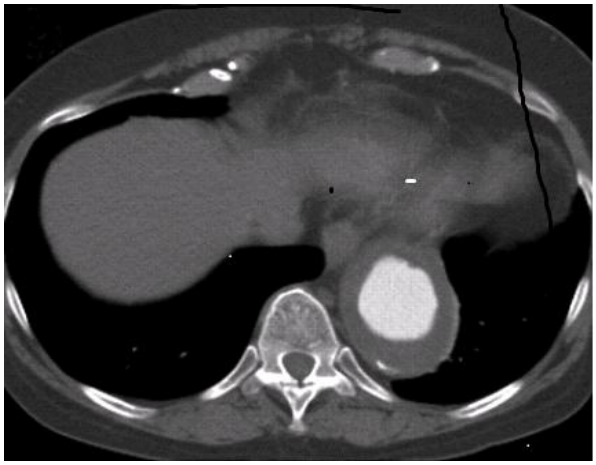

Fig. 3. Abnormal Image

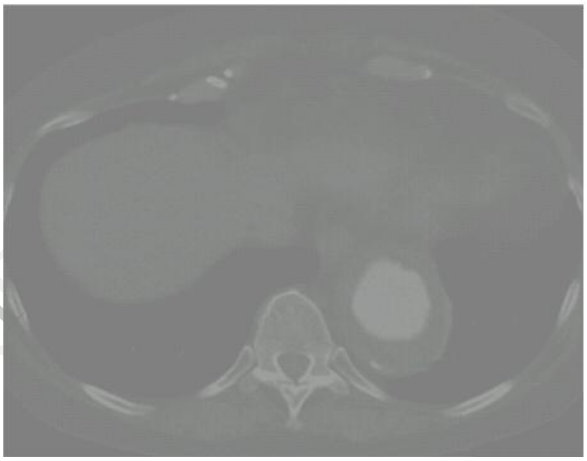

Fig. 4. Enhanced Image

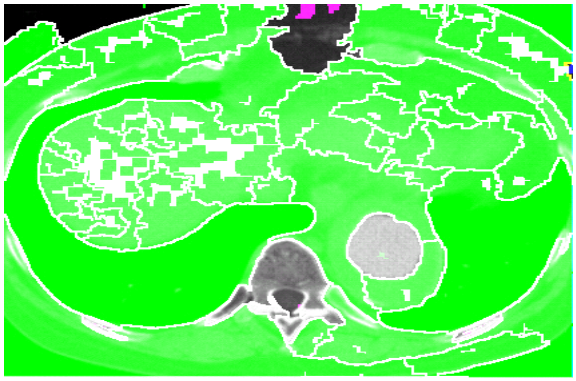

Fig. 5. Marker Super Imposed Image

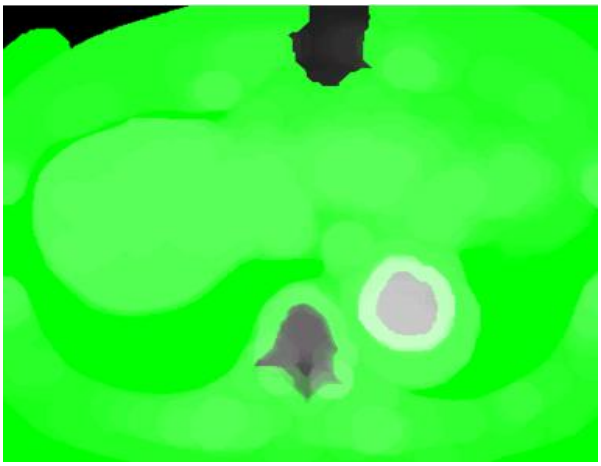

Fig. 6. Extracted Cancer Nodule

V. CONCLUSION

In this paper we are going to solve the over segmentation problem and the main contribution is to detect the cancer, even micro size nodule to be identified by using the modified watershed technique. The main reason for over segmentation problem is improper selection of marker and the lack of noise removal in the enhanced image. This problem can be eliminated by using the wiener filter and the modified watershed technique.

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