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Review Article

A Review of Techniques for Lung Cancer Detection

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Abstract

Image processing techniques are widely used in the medical field for image improvement in earlier detection and treatment stages. Here, time factor is crucial to discover the abnormality in target images, especially in cancer tumors such as lung cancer. Image quality and accuracy are the core factors. Image quality assessment and improvement depend on the enhancement stage where a low pre-processing technique is used, which is based on Gabor filter within Gaussian rules. Following the segmentation rules, an enhanced region of the object of interest that is used as the foundation of feature extraction is obtained. It focuses on locating nodules (early symptoms of the diseases), which appear in the patients' lungs. The aim is to computerizing these selections. The available lung cancer images and its database are passed in three stages: pre-processing, feature extraction and lung cancer cell identification, to achieve higher quality and accuracy in the experimental results.

Keywords: *Lung Cancer Detection, Gabor Filter, FFT Filter, Image Processing.*

1. Introduction

Cancer is the disease of abnormal cells multiplying and growing into a tumor. When the cells are those of the lungs, it is called Lung Cancer. Cancer cells may be transported away from the lungs in blood or lymph fluid that surrounds lung tissue. Lymph nodes are located in the lungs and in the center of the chest. Lung cancer mostly spreads towards the center of the chest because the natural flow of lymph out of the lungs is towards the center of the chest cavity. Metastasis is when a cancer cell leaves the site where it originated and moves into a lymph node or to another part of the body via the blood stream. Cancer that originates in the lung is called primary lung cancer. There are several types of lung cancer and are divided into two main groups: small cell lung cancer (SCLC) and non-small cell lung cancer (NSCLC) having three subtypes: Carcinoma, Adenocarcinoma and Squamous cell carcinoma. India contributes to one million of the current 5 million deaths in world, and 2.41 million in developing countries. By 2020, this figure is projected at 1.5 million. In a trend that's baffling scientists, the Indian Council of Medical Research (ICMR), after studying lung cancer data of 24 years (1982-2005), has found that while new cases of lung cancer per one hundred thousand male population has increased by around 160% in Chennai, 100% in Bangalore and 40% in Delhi during this period, such cases have fallen by 60% in Mumbai. In 2014, estimated new cases are 224,210 and estimated deaths are 159,260. Smoking is responsible for upwards of 80% of all lung cancers worldwide. In India, smoking is prevalent in 29% of adult males, 2.5% of adult females, 11.7% of male collegians, 8.1% among school children and adolescents (SIRO, *et al*, siroclinpharm.com). A quarter of the cigarette or beedi smokers in India would be killed by tobacco at the ages of 25-69 years, losing 20 years of life expectancy. Non-smokers account for 15% of lung cancer cases and these cases are often attributed to a combination of genetic factors, radon gas, asbestos, pesticides and air pollution including passive smoking. Farmers end up with lung cancer, mostly because they rely heavily on the use of chemical pesticides to get rid of their crop pests. In spite of many technological advances in radiological and molecular diagnostic techniques, the ideal screening marker to ensure early detection of lung cancer has still not been found.

Histological diagnosis and staging is vital for selecting the form of therapy in patients with lung cancer. Stages I and II are agreeable to surgery. However, advanced stage III and IV need a combination of surgery, chemotherapy and radiotherapy. Although NSCLC is sometimes treated with surgery, the complex and metastatic NSCLC and SCLC usually react better to chemotherapy and radiation. In recent years image processing is used widely in several medical areas for improving earlier detection and treatment stages, in which the time factor is vital to discover the disease in a patient as early as possible. Diagnosis is chiefly based on CT images. Our current work focuses on

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locating nodules, early symptoms of the cancer, appearing in patient's lungs. A modified Watershed segmentation approach is used to isolate a lung in a CT image, and then a small scanning window is applied to check whether any pixel is component of a disease nodule (B. Zhao, *et al*, 2003). Most of the nodules can be detected if the process parameters are carefully selected. Linear filters are used to extract useful feature representations to be used for classification problems in computer vision. One specific filter is based on the seminal work of Dennis Gabor. We are aiming at performing a comparative study of the conventional methods and Gabor Filtering technique. We passed the available lung cancer images and its database in three stages: pre-processing, feature extraction and lung cancer cell identification; to achieve higher quality and accuracy in the experimental results (A. Chaudhary, *et al*, 2012).

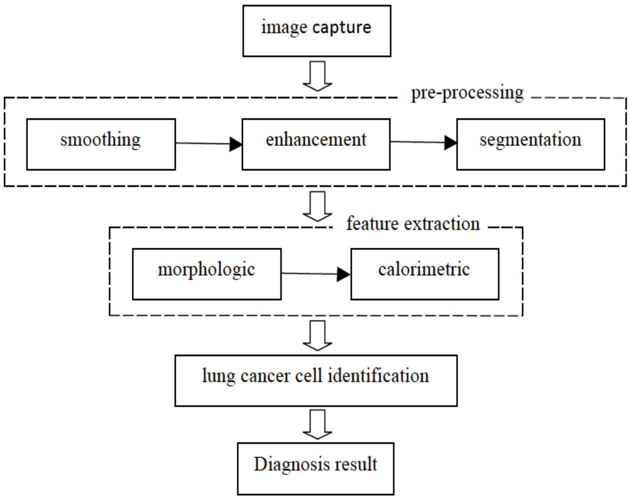


Fig. 1 Lung cancer image processing stages

2. Methodology

Lung cancer is the most widespread and dangerous cancer in the world according to stage of discovery of the cancer cells in the lungs, so the early detection of the disease plays an essential role to avoid serious advanced stages, which helps to reduce its degree of distribution. Lung Cancer Detection System (LCDS) uses convolution filters with Gaussian pulse to smooth the cell images. The color and contrast of the images are enhanced. Then the nuclei in the images are segmented by a method called thresholding. All of these are simple digital image processing techniques. Following that, LCDS employs morphologic and colorimetric techniques to extract the features from the images of the nuclei. The extracted morphologic features include the perimeter of the region, roundness of the area, and rectangleness of the nucleus. The extracted colorimetric features include the color components: red, green, blue; illumination, saturation, variation in the red and blue components, and the fraction of blue component in the nucleus.

3. Implementation Process

In this, to obtain more accurate results we divide the work into the following three stages:

- Image Enhancement: To improve the image and eliminate the noise, corruption or interference, three methods are used: Gabor filter (has the best results), Auto enhancement algorithm, and Fast Fourier Transform (FFT).
- Image Segmentation: To segregate and segment the enhanced images, the methods used are: Thresholding approach and Marker-Controlled Watershed Segmentation approach (which gives better results than thresholding).
- Features Extraction stage: To obtain the specific features of the enhanced segmented image using Binarization and Masking Approach.

4. Image Enhancement

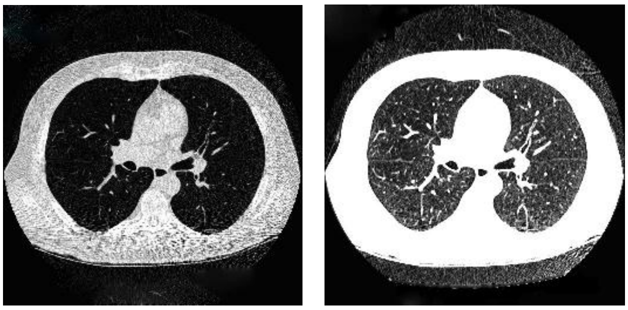
The pre-processing of the image starts with image enhancement; the aim of which is to improve the perception of information in the image for human viewers, or to provide better interpretability of the input for other computerized image processing techniques. Image enhancement is a way to improve the quality of image, so that the resulting image is superior to the original one. It also involves the process of improving the quality of the digitally stored image by altering the image with MATLAB™ software. Image enhancement techniques belong to one of two broad categories:

- Spatial domain techniques, which operate directly on pixels.
- Frequency domain techniques, which operate on the Fourier transform of an image.

On the medical images, three types of enhancement techniques were carried out: Gabor filter, Fast Fourier transform, and Auto-enhancement (M.S. Al-Tarawneh, *et al*, 2012). When it comes to human perception, there is no general theory for determining what good image enhancement is; but by comparing experimental results we can come to a conclusion.

4.1 Gabor Filter

Dennis Gabor first introduced this to be used for 2D images (CT images). The Gabor function has been a very useful tool in computer vision and digital image processing, especially for analyzing texture, due to its optimal localization properties operating in both, spatial and frequency domain. The image enhancement based on Gabor function is an excellent local and multi-scale decomposition in terms of logons that are simultaneously (and optimally) localized in space and frequency domains. A Gabor filter is a linear filter whose impulse response is defined by a harmonic function multiplied by a Gaussian function. As a result of the multiplication-convolution property (Convolution theorem), we observe that the Fourier transform of the impulse response of a Gabor filter is the convolution of the Fourier transform of the harmonic function and the Fourier transform of the Gaussian function (H. Ke, *et al*, 2012). The observed enhancement percentage in this method was equal to a considerably high 80.735%.



(a)Original Image (b) Enhanced by Gabor

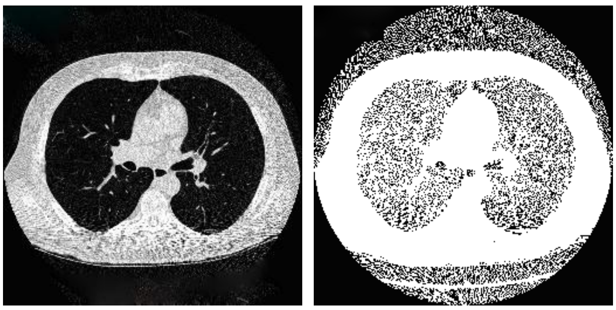
Fig.2 The result of applying Gabor filter

4.2 Auto Enhancement Technique

Auto enhancement is a relatively simple mathematical method and is strongly dependent on subjective observation and statistical calculations such as mean and variance. Hence there is no general output pattern as the results vary. The enhancement percentage in this method was equal to 38.025%.

4.3 Fast Fourier Transform Technique

Fast Fourier Transform technique operates on the Fourier transform of an image. The frequency domain in which each image value at image position F represents the amount that the intensity values in image I varies over a specific distance relative to F. Fast Fourier Transform (FFT) is a faster adaptation of the Discrete Fourier Transform (DFT). The FFT utilizes clever algorithms to obtain the same results as DTF, but is more time efficient. Figure 3 shows the effect of applying FFT on original image, where FFT method has an enhancement percentage of 27.51%.



(a) Original Image (b) Enhanced by FFT

Fig.3 The result of using FFT

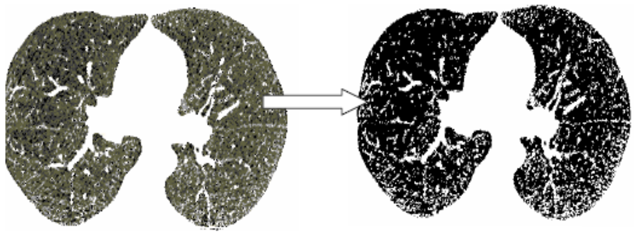
From the above 3 methods for image enhancement, we see that application of Gabor Filter gives the highest percentage of enhancement for a given image sample. Hence in the further stages, we use the image sample enhanced by Gabor filtering as the input.

5. Image Segmentation

Image segmentation is the next essential process for image analysis. Many of the existing techniques for image recognition depend highly on the result of segmentation. Segmentation divides an image into regions that constitute the image. The segmentation of images in 2D has many useful applications in the medical sector: estimation of volume and visualization of objects of interest, detection of abnormalities (such as tumors), tissue quantification and classification, are among the few (S. Kakeda, *et al*, 2004). The objective of segmentation is to change the representation of an image into something more meaningful and easier to analyze. Image segmentation is generally used to locate objects and boundaries in images. To be more precise, image segmentation is the process of assigning a label to each pixel in an image such that the pixels with the same label share certain visual characteristics. The result of segmentation is a set of similar segments that collectively make up the entire image. All pixels in a given region are similar with respect to some characteristic or computational property, such as color, intensity or texture. Adjacent regions greatly differ with respect to the same characteristics. Segmentation algorithms are based on one of two basic properties of intensity values: discontinuity and similarity. Discontinuity is to partition the image on the basis of abrupt changes in intensity, such as edges in an image. Similarity is based on partitioning the image into regions that are similar according to some predefined criterion. Histogram thresholding approach falls under this category.

5.1 Thresholding Approach

Thresholding is a non-linear operation, which converts an input gray-scale image into an equivalent binary image. Here the two levels (0 and 1) are assigned to pixels depending on whether they are below or above the specified threshold value.



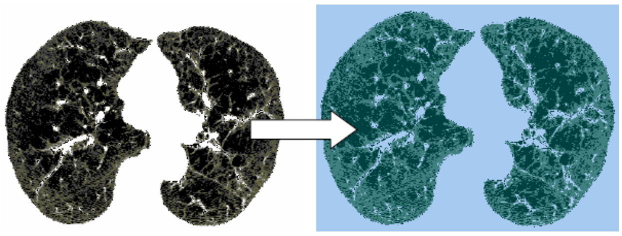
(a) Enhanced by Gabor (b) Segmented by thresholding

Fig.4 Enhanced image by Gabor filter and segmentation using thresholding approach

Thresholding uses Otsu's method which employs a gray thresh function, which computes global image threshold values. Otsu's method selects threshold by statistical criteria. Otsu's method minimizes the weighted sum of intra-class variances of the object and background pixels of the image to obtain an optimum threshold. Minimization of intra-class variances is equivalent to maximization of inter-class variance. This method gives adequate results for bimodal histogram images. Threshold value by this method will be between 0 and 1, after achieving this value we can segment an image based on it. Figure 4 shows the result of applying thresholding technique.

5.2 Watershed Segmentation Approach

Marker-controlled watershed segmentation technique extracts seeds, which indicate the presence of objects or background at specific locations. There Marker locations are then set to be the regional minima within the topological surface and the watershed algorithm is applied. Separating touching objects in an image is one of the complex image processing operations. The watershed transform is often used to solve this problem. The watershed segmentation can segment unique boundaries from an image. The advantage of watershed segmentation is that it produces a unique solution for a particular image input. One disadvantage of watershed segmentation is that the final boundaries of the segmented region lack smoothness.



(a) Enhanced by Gabor (b) Segmented by Watershed

Fig.5 Enhanced image by Gabor filter and Segmentation using Marker-controlled Watershed approach

According to the experimental assessment during the segmentation stage, the Watershed Segmentation approach has more quality and accuracy of 85.165% than the Thresholding approach's 81.835%.

6. Image Features Extraction

The Image features Extraction stage is a very important stage in image processing which uses algorithms and techniques to detect and isolate various desired portions or shapes (features) of an image, which is essential to predict the probability of lung cancer presence. The objective is that the features should carry enough information about the image and not require any domain-specific knowledge for their extraction. The sequence of stages starting from image enhancement, image segmentation and cropping, and finally feature extraction gets introduced. Feature extraction is a vital stage that results in determining the normality or abnormality of an image. Two approaches fall under this category: first is Binarization and the second is Masking. Both of these methods are based on lung anatomy and related information of lung CT imaging.

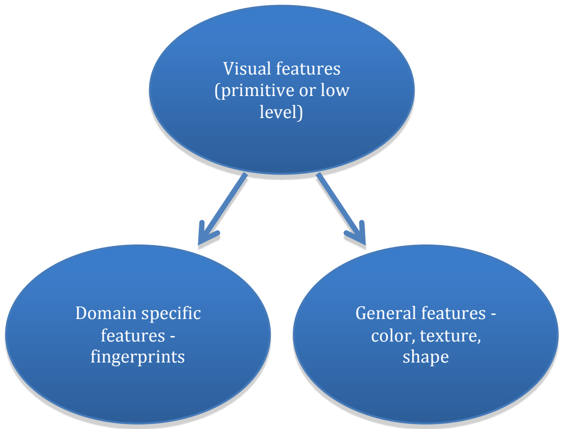


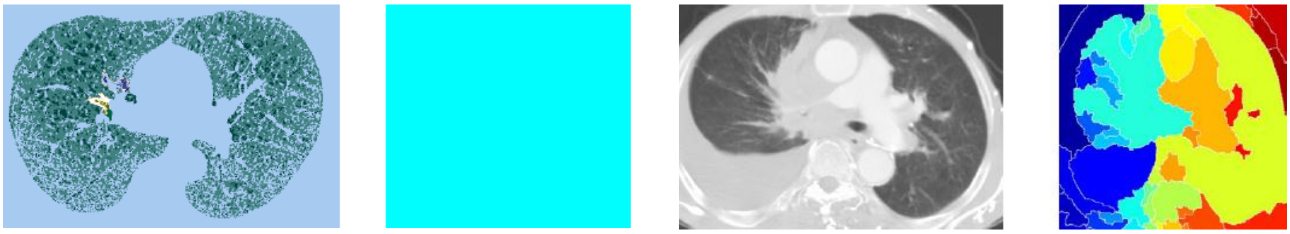
Fig.6 Visual Features Extraction Types

6.1 Binarization Approach

Binarization approach is based on the fact that in normal lung images, the number of black pixels is much greater than white pixels. We start off by counting the number of black pixels for normal and abnormal images to get an average to use later as a threshold. For the new image, if the number of the black pixels is greater that the threshold, then it indicates that the image is normal. Otherwise, if the number of black pixels is less than the threshold, it indicates that the image in abnormal. The threshold value that is used in this here is 17178.48. The true acceptance rate (TAR) is 92.86% and false acceptance rate (FAR) is 7.14%.

6.2 Masking Approach

Masking method depends on the fact that the masses appear as white connected areas inside the lungs with as increase in the percentage of cancer present. Combining Binarization and Masking together helps us to take a decision whether the specific case is normal or abnormal. The appearance of solid blue color indicates that it is normal, whereas the appearance of RGB masses indicates the presence of cancer. The true acceptance rate (TAR) is 85.7% and false acceptance rate (FAR) is 14.3%. Figure 7 shows normal and abnormal image results obtained by implementing Masking approach using MATLAB.



(a) Image enhanced by Gabor, (b) The resultant image segmented by watershed indicates normality (c) Abnormal image (d) Resultant image indicates abnormality

Fig.7 Normal and Abnormal images using Masking

Table 1: Sub and final averages for three techniques used for image enhancement stage

Subject	Auto Enhancement	Gabor Filter	FFT Filter
Sub 1	37.95	80.975	27.075
Sub2	47.725	80	36.825
Sub 3	36.825	79.5	25.625
Sub 4	34.775	81.8	25.175
Sub 5	32.85	81.4	22.85
Final Average	38.025	80.735	27.51

Table 2: Comparison between different image enhancement techniques

Parameter	FFT Filter	Gabor Filter
Application	Image enhancement in finger prints scanning.	Image enhancement in cancer detection and finger print scanning.
Efficiency	27.51%	80.74%
Domain	Frequency domain only.	Frequency and Spatial domain.
Advantages	(1) It is extra possible for modelling visualization (the illustration method does not appear to calculate Fourier transforms); and	(1) Exploiting joint localization in both spatial and regularity fields;
	(2) It authorizes local dispensation which is limited to regions of attention and non rectangular shapes. We suggest a considerably enhanced spatial area accomplishment with admiration to the unique work	(2) Flexibility; Gabor Filter (GF) can be liberally adjusted to a range of spatial spots, frequencies and directions, using arbitrary bandwidths;
		(3) GF are the only biologically possible filters with direction selectivity that can be accurately articulated as a sum of only two separable filters
Disadvantages	(1) The image displayed is not of sufficient brightness.	(1) Complex calculations
	(2) Less efficient than Gabor	(2) Slower than FFT
Type of Filter	Digital Filter	Linear filter

7. Comparative study

7.1 Comparison between Image Enhancement Techniques

Table 1 and 2 shows a comparison of the three mentioned techniques used for image enhancement. According to the values shown in the Table 1, we can conclude that the Gabor Enhancement is the most suitable technique for image enhancement. Observing the images enhanced by this method, we notice that new image details have appeared, in addition to good clearance and brightness shown by the enhanced images.

Conclusions

Lung cancer is the most dangerous and widespread cancer in the world with respect to the stage of discovery of cancer cells in the lungs. This is clear indication that the process of detecting the disease plays an essential role to avoid serious advanced stages and to treat more cases across in the world. An image processing technique is needed for earlier disease detection and treatment stages. Time factor is taken into account to discover the abnormality in target images. Image quality and accuracy are the core factors of any method. Image quality assessments for enhancement stage were adopted on low pre-processing techniques based on Gabor filter within Gaussian rules. The proposed technique is efficient for segmentation principles for obtaining a region of interest for subsequent feature extraction. The proposed technique gives very promising results when compared to other techniques; hence Gabor filter is the most efficient image enhancement technique for lung cancer detection.

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