Segmentation of Lung Nodule Using Image Processing Techniques from CT Images

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----------ABSTRACT----------

Lung cancer is the most prevalent and hazardous disease in the world having highest mortality rate among all other types of cancers like breast, liver, brain, skin etc.. There is a great need to detect it in its early stage to provide a great chance of survival to the patient. It is possible only when lung nodules will be automatically segmented through image modalities. The main aim of this study is to overcome the above problem from CT images.

The medical image segmentation with accuracy is a prognostic factor in the diagnosis of lung cancer. Manual segmentation of lung nodules form CT image is a challenging & crucial task. A semi-automated segmentation method is proposed to segment lung nodules from CT images which can successfully segment a nodule provided that the parameters are set properly.

Keywords – Cancer, CT Images, Image modalities, Lung Nodule, Medical Image Segmentation

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1. Introduction

Lung cancer is the most prevalent and hazardous disease in the world having highest mortality rate among all other types of cancers like breast, liver, brain, skin etc. Today, a number of techniques are available to diagnose the lung disease, such as X- ray, CT, MRI Scan, PET-CT etc. but majority of death occurs only due to diagnosis in later stages.

Nowadays for lung cancers, computed tomography is more reliable and the most effective image modality among all modalities due to high accuracy and sensitivity in ruling out size of tumor and lymph node metastases [6]. X-rays highlights vital parts of the body, whereas CT serve thorough outlook of the soft tissues, including lungs, muscle tissue and blood vessels. While Roentgenogram provides a 2-D image of body, a sliced view of the body is depicted by CT images.

Advantages and disadvantages of CT images are acknowledged by Sharma N. et al in his study [7]. Despite the disadvantages, CT modality plays an important part in the evaluation of lung nodule, tuberculosis, pneumonia, emphysema, inflammation etc.

As detection of the lung nodules from CT images is more challenging, there would be a need to develop a more reliable and an effective CAD system to detect the disease in its early stage, thus increasing the possibility of survival to the patients. [2]

In this study we proposed that preprocessing and segmentation of image is a more effective technique to diagnose the disease in its early stage that would enhance the quality of the diagnosis speedy.

By keeping the goals of CAD [7] in mind when achieving the results, segmentation of the image seems to be necessary. Segmentation is described as a method of dispensing image pixels into meaningful, usually connected, regions which are homogenous with respect to some criterion. In various image processing solutions, it is a vital staircase. Segmentation is of chief importance in medical imaging for image measurements, feature extraction, and display of image. Various applications it may be useful to classify image pixels into anatomical regions of body. Although, algorithms and segmentation techniques have been proposed and implemented, the problem remains unsolved. The higher efficient lung segmentation helps in analysis and diagnosis for lung diseases [3].

Techniques of image segmentation can be grouped into three based on the following parameters

- Intensity (example thresholding)
- Region (example split and merge and region growing)
- Other methods (example edge, motion and texture based segmentation)

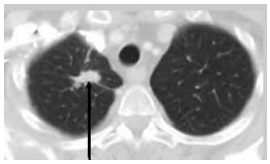
2. Methodology

The preprocessing steps of the proposed system can identify the appropriate region affected by cancer. The aim of preprocessing is to get better quality of the acquired

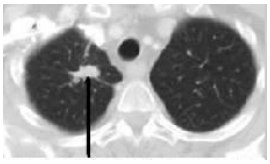
image. Preprocessing involves image enhancement, noise removal, thresholding, segmentation. Every progression is successfully completed by using MATLAB software which provides a multi-platform environment for the user. This tool is used for prototyping, analysing the data, and provides a built-in support for various operations. Also, it has an enriched capability of graphics with a user friendly programming language environment. In the software development cycle, it leads to precious time savings.

2.1 Preprocessing

At first we convert the image to gray scale [3] image that contain only brightness information. These images are determined as a two dimensional array of pixels which is using 8 bits/pixels. Here, zero pixel value correspond to black and white is for 255, with transitional values corresponding to varying shades of gray. Conversion of image into gray scale provides an advantage of reducing the processing time facilitating rapid algorithm production[6].



(a) Original image



(b) Grayscale image

Often the quality of the acquired image is not satisfactory due to factors such as blur, unnatural colors, noise, and artifacts. It is necessary to pre-process the image so that the irrelevant information or noise is removed. This process is called Image Enhancement i.e. it makes the image more useful for further processing. The reasons for doing this consist of highlighting interesting details, removing noise and making images more visually appearing.

To enhance the quality of an image, it is necessary to assess its features. This requires some quality quantification & assessment tools. Enhancement techniques can be grouped into two broad classes as frequency domain and spatial domain. Spatial domain includes direct manipulation of image pixels, while manipulation of fourier transform or wavelet transform of an image comes under frequency domain.

For the moment, this study concentrated on techniques that operate in the spatial domain i.e. Histogram Equalization.

2.2 Histogram Equalization

The frequency of occurrence of each gray level in the image is represented by a graphical representation known as histogram of a monochrome image. It reassigns the brightness values of pixels based on the image histogram. Histogram- modeling techniques are used to modify the image so that its histogram has a desired shape. This is useful in stretching the low-contrast levels of images with narrow histograms. Histogram modeling has been found to be a powerful technique because they are simple, fast and with them acceptable results for some applications can be achieved. The goal of histogram equalization is to provide uniformity which facilitates further visually satisfying results. Mathematically, each individual histogram can be expressed as

$$h(k) = n_k = \text{card}\{(x , y) \mid f(x , y) = k \} \quad (1)$$

Here, k = 0,1,…, L-1, where L is the number of gray levels of the digitized image, and card(…) denotes the cardinality of a set, that is, the number of elements in that set(n_k).

Mathematically, a normalized histogram can be defined as

$$p(r_k) = \frac{n_k}{n}$$

Where n is the total number of pixels in the image and $p(r_k)$ is the probability (percentage) of the k^{th} gray level (r_k).

Figure (c) represents the histogram of the original image with one bar per gray level in which the height of the bar is proportional to the number (or percentage) of pixels that correspond to that particular gray level. Figure (d) signify the uniform histogram after equalization using imhist function.

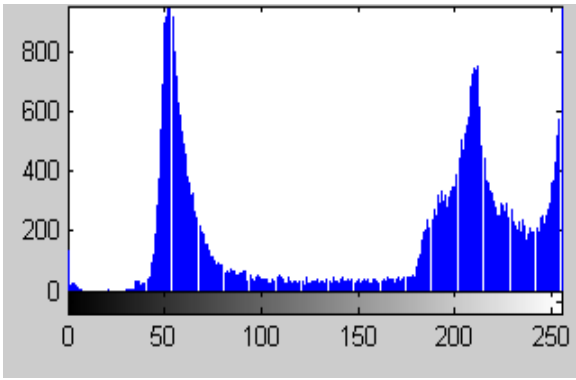


Figure (c) Histogram of original image

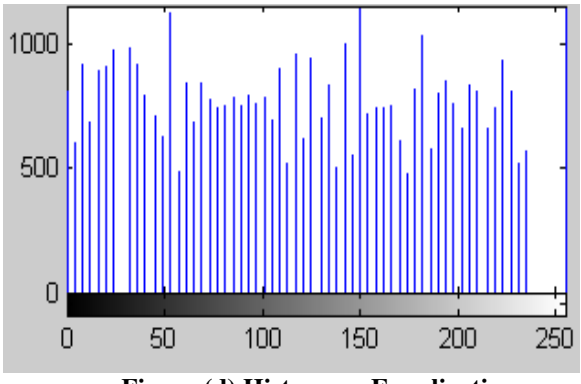


Figure (d) Histogram Equalization

2.3 Noise Removal

Apart from contrast and intensity manipulation image enhancement includes noise removal, filtering etc which make the image suitable for further processing [2]. Image smoothing is useful for giving a softer visual effect and for removing noise. Noise can be defined as any unwanted information that contaminates an image. The presence of

noise in an image can be due to several sources like analog-to-digital conversion, camera sensors, communication channels etc. resulting in different types of noises like

- Gaussian
- Impulse (Salt and pepper)
- Rayleigh
- Speckle
- Uniform
- Exponential
- Gamma(Erlang)

Enhancement of the acquired image focus on removing noise that is the product of low-level data errors. Therefore, it is vital to remove noise to improve the quality of the acquired image and to facilitate the further processing such as edge detection, segmentation and analysis etc. Filtering an image to smoothen noise while maintaining the details of the image preserved is one of the most important issues.

Median Filter is the most admired filter among all others types. It is a nonlinear common enhancement digital filter [4]. It selects the middle pixel value form the ordered set of values within the m x n neighbourhood (W) in the region of the reference pixel. Median filter is advantageous from smoothing filters as it provides:

- No reduction in contrast across steps
- No shifting of boundaries (no disturbance in edges) as well as does not degrade edges,
- An effective way for smoothing additive white noise in removing impulses.

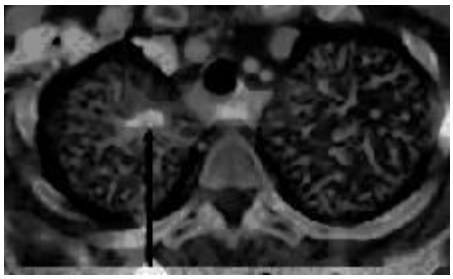


Figure (e) Filtered image

Thresholding

The purpose of the lung segmentation required for the CAD from CT scan images is to essentially separate the voxels corresponding to the lung cavity in the axial CT scan slices from the surrounding lung anatomy. An optimal thresholding which selects the threshold based on the object and background pixel means.

The simplest method within the intensity based methods is image thresholding. Because of its simplicity, intuitive properties and ease of implementation it has become a well accepted method. In machine visual systems, thresholding is a common preprocessing step. The fundamental setback of thresholding is the alteration of the image with several gray levels into another image with smaller quantities of gray levels, usually two only.

The best move towards optimal thresholding was projected by Otsu and implemented by graythresh which compute global threshold. This method is based on threshold selection criteria. Based on this method, threshold value will be between 0 and 1. After achieving this value we can segment an image based on it [1].

Figure (f) Threshold Image

2.4 Morphological operations

The main morphological operations are dilation, erosion, closing, opening and the hit-or-miss transform. Among these apply morphology closing (dilation and erosion) on the image. It fills the indentation caused by the pulmonary vessels [5]. The effect of dilation is to “grow” or “thicken” objects in a binary image whereas, in erosion, outcome is to “shrink” or “thin” objects. The extent and direction of the thickening and thinning are controlled by the shape and size of the structuring element. In the present study structuring element is disk of radius is one. Dilation is implemented by using function imdilate() and erosion by imerode().

Figure (g) Eroded Image

Figure (h) Dilated Image

3. Conclusion

Lung cancer is the widespread disease in the world which is most dangerous and have highest mortality rate among all other types of cancers. The aim of this study is to provide systematic and quantitative measurement on CT images so that physicians can diagnose the nodule more effectively and more accurately. By this work, the acquired results are satisfactory to detect the nodule as mentioned above. This method has improved the efficiency of the CAD system after applying the preprocessing on the image.

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