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Modified Watershed Transform For Lung Cancer Detection

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Abstract: **The major cause of cancer death is lung cancer. Detection of cancer in the early phase can provide more treatment options, less invasive surgery and increases the survival rate. For lung cancer, if the disease is detected in time, the survival rate of patient increases from 14 to 49% in recent 5 years. It is the most dangerous and widespread disease in the world. The cancer cells present in lung causes lung cancer disease. This cells detection is very important issue for medical researchers. The chances of an effective treatment will significantly increases with early detection.Computed Tomography (CT) is an imaging procedure that uses special x-ray equipment to create detailed pictures, or scans, of areas inside the body. It is also called Computerized Tomography and Computerized Axial Tomography (CAT).The CT images are used which are more efficient than X-ray. MATLAB is widely used software for the study of lung cancer detection from CT scan images. The process includes image pre-processing, image segmentation, feature extraction and classification technique. This present work proposes a method to detect the cancerous cells effectively from the lung CT scan images. It will minimize the detection error made by the physician's naked eye.**

Keywords: **Cancer Detection; Image Processing; Image Enhancement; Thresholding; Watershed Transform; Gabor Filter; Tomography;**

I. INTRODUCTION

Recently, the image processing mechanisms are used widely in different medical areas for increasing earlier detection and treatment stages. The time is very significant factor to discover the disease in the patient as possible as fast. Its early detection increases the chances of an effective treatment.

In 2005, approximately 1,372,910 new cancer cases are predictable and about 570,280 cancer deaths are expected to occur. It is expected that there will be 163,510 deaths from lung cancer, which forms 29% of all cancer deaths. [1] When cells start to grow out of control, cancer begins in a part of the body. The cancer cell starts because of out of control expansion of abnormal cells.

Lung cancer is a disease of abnormal cells multiplying and increasing into a tumour. Cancer cells continue to increase and form new abnormal cells. Many of them can be diagnoised. So finding of lung cancer earlier is most important for successful treatment. Diagnosis is mainly based on CT scan images. Cancerous tumour starts in the part of lung is called primary lung cancer. Following are the types of this lung cancer and these are divided into two main types:

1. Small cell cancer

2. Non small cell cancer

In this, current work focuses on finding tumour and its stages using Marker-controlled Watershed segmentation to isolate a lung of a CT image.

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II. LITERATURE SURVEY

Region growing algorithm proposed for segmentation of CT scan images of the Lung. This algorithm starts with a seed pixel and also checks other pixels that surround it. It determines the most similar one and, if it meets certain criteria, it will include in the region. The region is developed by examining all unallocated neighboring pixels to the region.

In proposed an approach for detection of cancer cells from Lung CT scan images. This work presents a method to detect the cancer cells from the CT scan image. It reduces the error in the detection part made by the doctors for medical study. It is based on Sobel edge detection and label matrix. Sobel operator helps to locate the edges in an image. It does so by finding the image gradient. Image gradient gives the change in the intensity of the image. Also in [4] a system using Computer Aided Diagnosis (CAD) for finding the edges from CT scan images of lung for detection of diseases is used. Thresholding algorithm [5] gives filtering to detect the sputum cell from the raw image for early detection. A novel method, watershed transformation [6] is presented for image segmentation. Morphological operations which are opening and closing operations are used to process the gradient image. It is used to eliminate the over segmented area and to reconstruct the morphological gradient which can maintain the shape of gradient image.

The main idea of this is to detect the tumour and decide whether it is cancerous or not. It also finds the lung cancer stage and gives more accurate result by using different enhancement and segmentation techniques.

III. PREVIOUS METHODS

Recently, image processing techniques are widely used in several medical areas for image improvement in earlier detection and treatment stages, where the time factor is very important to discover the abnormality issues in target images, especially in various cancer tumours such as lung cancer, breast cancer, etc. Image quality and accuracy is the core factors of this research, image quality assessment as well as improvement are depending on the enhancement stage where low pre-processing techniques is used based on Gabor filter within Gaussian rules. Following the segmentation principles, an enhanced region of the object of interest that is used as a basic foundation of feature extraction is obtained. Relying on general features, a normality comparison is made. In this research, the main detected features for accurate images comparison are pixels percentage and mask-labelling.

Lung cancer is a disease of abnormal cells multiplying and growing into a tumour. Cancer cells can be carried away from the lungs in blood, or lymph fluid that surrounds lung tissue. Lymph flows through lymphatic vessels, which drain into lymph nodes located in the lungs and in the centre of the chest. Lung cancer often spreads toward the centre of the chest because the natural flow of lymph out of the lungs is toward the centre of the chest. Metastasis occurs when a cancer cell leaves the site where it began and moves into a lymph node or to another part of the body through the blood stream [1]. Cancer that starts in the lung is called primary lung cancer. There are several different types of lung cancer, and these are divided into two main groups: Small cell lung cancer and non-small cell lung cancer which has three subtypes: Carcinoma, Adenocarcinoma and Squamous cell carcinomas. The rank order of cancers for both males and females among Jordanians in 2008 indicated that there were 356 cases of lung cancer accounting for (7.7 %) of all newly diagnosed cancer cases in 2008. Lung cancer affected 297 (13.1 %) males and 59 (2.5%) females with a male to female ratio of 5:1 which Lung cancer ranked second among males and 10th among females [2]. Figure 1 shows a general description of lung cancer detection system that contains four basic stages. The first stage starts with taking a collection of CT images (normal and abnormal) from the available Database from IMBA Home (VIA-ELCAP Public Access) [3]. The second stage applies several techniques of image enhancement, to get best level of quality and clearness. The third stage applies image segmentation algorithms which play an effective role in image processing stages, and the fourth stage obtains the general features from enhanced segmented image which gives indicators of normality or abnormality of images.

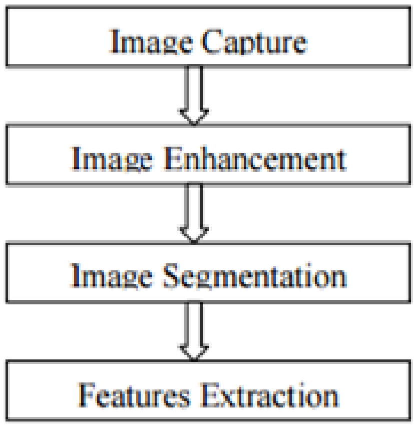


Figure 1. Lung cancer image processing stages

Image Enhancement:

The image Pre-processing stage starts with image enhancement; the aim of image enhancement is to improve the interpretability or perception of information included in the image for human viewers, or to provide better input for other automated image processing techniques. Image enhancement techniques can be divided into two broad categories: Spatial domain methods and frequency domain methods. Unfortunately, there is no general theory for determining what “good” image enhancement is when it comes to human perception. If it looks good, it is good. However, when image enhancement techniques are used as pre- processing tools for other image processing techniques, the quantitative measures can determine which techniques are most appropriate [4]. In the image enhancement stage,three techniques are used.They are Gabor filter, Auto-enhancement and Fast Fourier transform techniques.

Gabor Filter:

Image presentation based on Gabor function constitutes an excellent local and multiscale decomposition in terms of logons that are simultaneously (and optimally) localization in space and frequency domains [5]. A Gabor filter is a linear filter whose impulse response is defined by a harmonic function multiplied by a Gaussian function. Because of the multiplication-convolution property (Convolution theorem), the Fourier transform of a Gabor filter's impulse response is the convolution of the Fourier transform of the harmonic function and the Fourier transform of the Gaussian function [6]. Figure 2 describes (a) the original image and (b) the enhanced image using Gabor Filter.

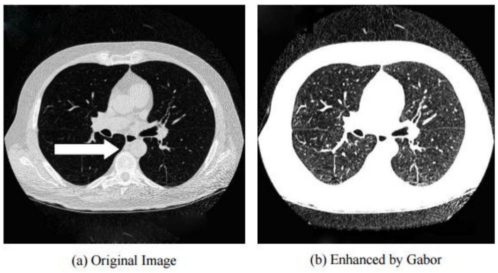


Figure 2. The result of applying Gabor enhancement technique

Auto enhancement method strongly depends on subjective observation and statistical operations such as mean and variance calculation. The enhancement percentage in this research was equal to 38.025%.

Image Segmentation:

Image segmentation is an essential process for most image analysis subsequent tasks. In particular, many of the existing techniques for image description and recognition depend highly on the segmentation results [7]. Segmentation divides the image into its constituent regions or objects. Segmentation of medical images in 2D, slice by slice has many useful applications for the medical professional such as: visualization and volume estimation of objects of interest, detection of abnormalities (e.g. tumours, polyps, etc.), tissue quantification and classification, and more [8]. The goal of segmentation is to simplify and/or change the representation of the image into something that is more meaningful and easier to analyse. Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in images. More precisely, image segmentation is the process of assigning a label to every pixel in an image such that pixels with the same label share certain visual characteristics [9]. The result of image segmentation is a set of segments that collectively cover the entire image, or a set of contours extracted from the image (edge detection). All pixels in a given region are similar with respect to some characteristic or computed property, such as colour, intensity, or texture. Adjacent regions are significantly different with respect to the same characteristics. Segmentation algorithms are based on one of two basic properties of intensity values: discontinuity and similarity. The first category is partitioning the image based on abrupt changes in intensity, such as edges in an image. The second category is based on partitioning the image into regions that are similar according to a predefined criterion. Histogram thresholding approach falls under this category.

IV. PROPOSED METHOD

In this, available lung CT scan images are passed through the system which is having following stages: pre-processing stage, segmentation stage, feature Extraction stage and classification

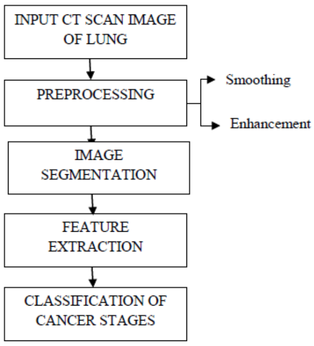


Figure 3. Flow Diagram of Proposed System

The Gaussian filter is used to smooth the input image in the preprocessing stage. As well as, in the pre-processing stage, Gabor filter is used for enhancement and thresholding and Marker-Controlled watershed transform is used for the segmentation purpose. After image segmentation, the features such as average intensity, perimeter, area and eccentricity are extracted from the detected tumour. Binarization process is done to decide whether it is cancerous tumour or not. Also, if there is cancerous tumour, the cancer stage is identified. In this image pre-processing stage, image smoothing is the first step. For smoothing, Gaussian filter is applied on the input image. Gaussian smoothing is very effective for removing noise. Gaussian removes high frequency components from the image. So it is a low pass filter. Smoothing reduces the noise and giving us a more accurate intensity surface. The mathematical equation for the Gaussian filter is as given in equation (1).

$$G(x, y) = \frac{1}{2\pi\sigma^2} e^{\frac{-(x^2+y^2)}{2\sigma^2}} \quad (1)$$

where x is the distance from the center on the horizontal axis, y is the distance from the center on the vertical axis, and σ is denoted as the standard deviation of the gaussian distribution. It determines the amount of smoothing. The output of Gaussian filter for figure 2(b) is shown in figure 4.

Figure 4. Smoothed Image

Next part in pre-processing is image enhancement stage. The function of image enhancement stage is to highlight the important information of image. In this step, better visual effects are performed on the image which enhance the human eye's distinguish ability of information. It is a way to improve the class of image, so that the final output image is better than the original one. For image enhancement, Gabor filter is used.

The Gabor function is a very helpful tool in image processing, texture analysis. It is a linear filter and its impulse response is derived from the multiplication of harmonic function and gaussian function. It is a band pass filter. It is used to increase the contrast between the nodule areas and other structure around it. The mathematical expression for the gabor filter is given in

equation (2).

$$g(x, y) = \exp(-\frac{x'^2+\gamma^2 y'^2}{2\sigma^2}) \cos(2\pi \frac{x'}{\lambda} + \varphi) \qquad (2)$$

$$x' = x\cos\theta + y\sin\theta \qquad (3)$$
$$y' = -x\cos\theta + y\sin\theta \qquad (4)$$

λ represents the wavelength of the sinusoidal wave.

- denotes for the orientation of normal to parallel stripes of gabor function.
- denotes phase offset.
- denotes standard deviation.
- is spatial aspect ratio.

The output image of gabor filter is shown in figure 5.

Figure 5. Enhanced Image using Gabor Filter

A. Image segmentation:

Segmentation is used to divide an image into different small regions or objects. It has many applications in the medical field for the segmentation of the 2D medical images.

It is an important process for most image analysis following techniques. There are various methods available for image segmentation. In this paper, thresholding and marker controlled watershed segmentation methods are used. Thresholding is the most effective tool for the image segmentation purpose. It is used to converts a gray scale image into a binary image. These two levels are assigned to pixels, below or above the particular threshold value. The image obtained from thresholding segmentation has smaller storage space, fast processing speed and ease in manipulation compared with gray level image which usually has 256 levels. The output of threshold image is shown in figure 6.

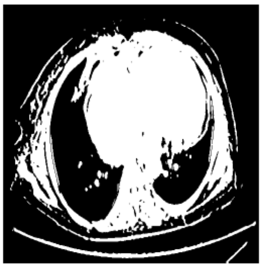


Figure 6. Threshold based segmented Image

The concept of watershed is well known in topography. Watershed segmentation is used to extract the region minimum value from an image. It determines the corresponding to the dividing line with the least value. Dividing line in the image gives the rapid change of boundary. This transform finds catchment basins and watershed edge lines in the image. It treats the image as a plane, where light pixels are high and dark pixels are low. The important drawback associated to the watershed transform is the over segmentation that usually results.

The output of watershed segmented image is shown in figure 7.

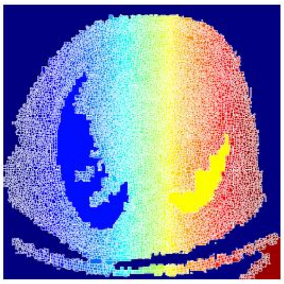


Figure 7. Watershed segmented Image

To overcome the drawbacks of this watershed segmentation i.e. over segmentation, the marker based watershed segmentation technique is used. It can segment boundaries from an image. Morphological operations are performed on the watershed segmented image to get final segmented image. Here the method is to use morphological operations called opening by reconstruction and closing by reconstruction to clean up the image. These operations will generate flat maxima inside each object which is located using imregionalmax. The output of marker based watershed segmented image is shown in figure 8.

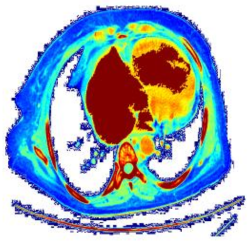


Figure 8. Marker-Controlled Watershed based segmented Image

After segmentation process, binarization process is done. In this approach, the total number of black pixels & white pixels are counted. If the total number of black pixels of input image is more than threshold, then the tumour is normal tumour. Otherwise, if the total number of the black pixels is less than the threshold then the tumour is cancerous tumour. By using this result, sensitivity and accuracy are calculated. To find these parameters, first calculate some of the conditions like true positive, false negative, true negative and false positive.

Sensitivity=TP/(TP+FN) (5)

Accuracy=(TN+TP)/(TN+TP+FN + FP) (6)

Here TP is True Positive, TN is True Negative, FN is False Negative and FP is False Positive. Sensitivity is defined as amount of true positives that are correctly recognized by a diagnostic test. Accuracy is defined as the amount of true results, which is either true positive or true negative. It measures the degree of reliability of a diagnostic test on a condition.In the CT scan lung image dataset, total 14 images are available. With the help of this dataset, the values of TP, FP, FN, TN, Sensitivity and accuracy are determined and given in Table 1.

Table 1. Detection accuracy of the proposed approach

Evaluation metrics	Thresholding	Marker controlled watershed transform
True Positive	13	13
False Positive	1	0
True Negative	0	1
False Negative	0	0
Sensitivity	1	1
Accuracy	0.92	1

By analysis, it is found that the Marker Controlled Watershed Transform performs superior than the existing algorithms. The results of the analysis have proved 100% of accuracy in Marker Controlled Watershed Transform algorithm by detecting the tumours from the CT scan lung images.

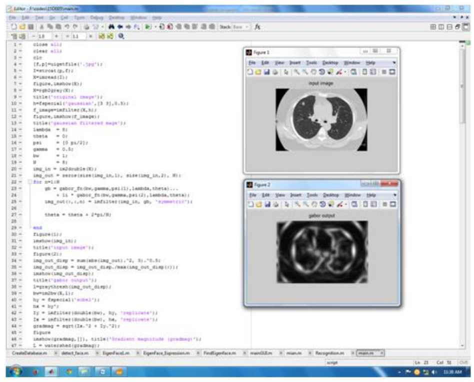
The features for example average intensity, area, perimeter and eccentricity are extracted and according to these features, tumour will be classified into the stages of cancer.

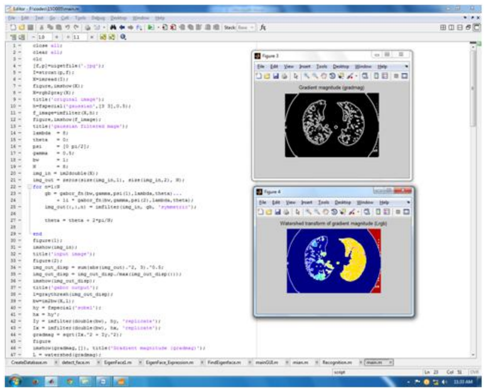
1. In stage I, the cancer tumour is small.

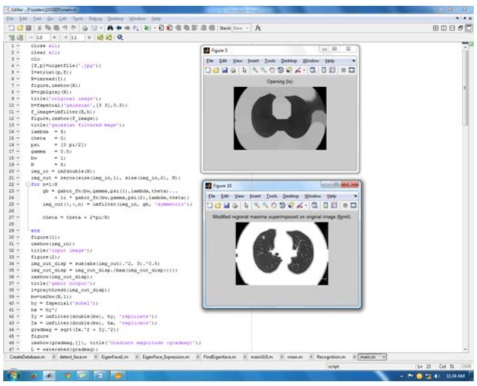
2. In stage II, the cancer tumour is limited to the chest.

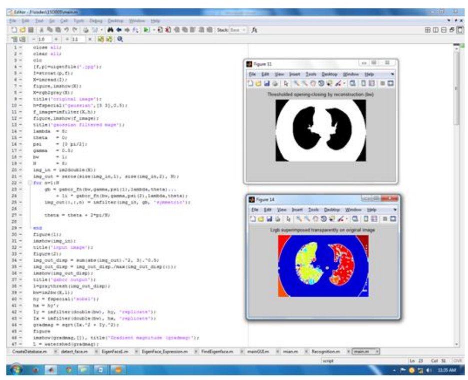
3. In stage III, cancer tumour reaches to other parts of the body

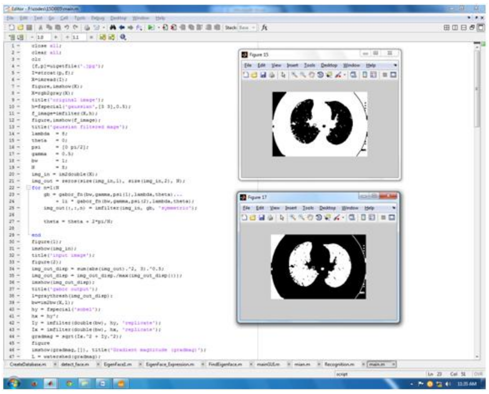
V. SIMULATION RESULTS

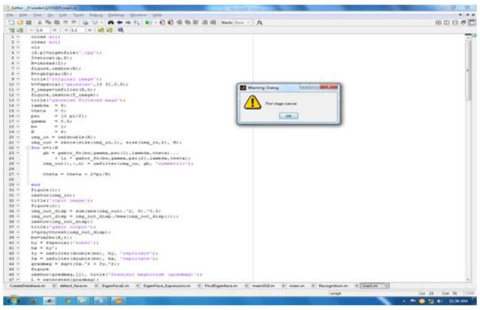












VI. CONCLUSION

The system consists of pre-processing, segmentation, feature extraction and final classification. The proposed marker controlled watershed segmentation technique separates the touching objects in the image. It provides best identification of the main edge of the image and also avoids over segmentation. It gives 100% accuracy compared to the thresholding algorithm. So it is efficient for segmentation. The proposed technique gives very promising results comparing with other used techniques.

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