

Detection of Lung Cancer using Marker-Controlled Watershed Transform

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Abstract: 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 detection is very important issue for medical researchers. The chances of an effective treatment significantly increases with early detection. Most commonly CT-images are used for processing because of their high resolution, better clarity, low noise and distortions. The Computed Tomography (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 and detection of tumour as it appears. 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 physicians' naked eye.

Keywords: Small-Cell Lung Carcinoma (SCLC), Non-Small-Cell Lung Carcinoma (NSCLC), Image Acquisition, Image Segmentation.

I. INTRODUCTION

Lung cancer also known as lung carcinoma is a malignant lung tumor characterized by uncontrolled cell growth in tissues of the lung. This growth can spread beyond the lung by the process of metastasis into nearby tissue or other parts of the body. Most cancers that start in the lung, known as primary lung cancers, are carcinomas [1]. The two main types are small-cell lung carcinoma (SCLC) and non-small-cell lung carcinoma (NSCLC).

A. Causes of Lung Cancer

The vast majority (85%) of cases of lung cancer are due to long-term tobacco smoking. About 10–15% of cases occur in people who have never smoked. These cases are often caused by a combination of genetic factors and exposure to radon gas, asbestos, second-hand smoke, or other forms of air pollution. Lung cancer may be seen on chest radiographs and computed tomography (CT) scans. Most commonly CT-images are used for processing because of their high resolution, better clarity, low noise and distortions.

Avoidance of risk factors, including smoking and air pollution, is the primary method of prevention. Treatment and long-term outcomes depend on the type of cancer, the stage (degree of spread), and the person's overall health. Most cases are not curable. Common treatments include surgery, chemotherapy, and radiotherapy. NSCLC is sometimes treated with surgery, whereas SCLC usually responds better to chemotherapy and radiotherapy. Cancer develops after genetic damage to DNA and epigenetic changes. Those changes affect the cell's normal functions, including cell proliferation, programmed cell death (apoptosis), and DNA repair. As more damage accumulates, the risk of cancer increases.

B. Signs of Lung Cancer

Signs and symptoms which may suggest lung cancer include:

1. Respiratory symptoms: coughing, coughing up blood
2. Wheezing or shortness of breath.
3. Systemic symptoms: weight loss, weakness, fever, or clubbing of the fingernails.
4. Symptoms due to the cancer mass pressing on adjacent structures: chest pain, bone pain, superior vena cava obstruction, or difficulty swallowing.

If the cancer grows in the airways, it may obstruct airflow, causing breathing difficulties. The obstruction can lead to accumulation of secretions behind the blockage, and predispose to pneumonia. Tumors in the top of the lung, known as Pancoast tumors, may invade the local part of the sympathetic nervous system, leading to Horner's syndrome as well as damage to the brachial plexus. Many of the symptoms of lung cancer (poor appetite, weight loss, fever, fatigue) are not specific. In many people, the cancer has already spread beyond the original site by the time they have symptoms and seek medical attention. Symptoms that suggest the presence of metastatic disease include weight loss (headaches, fainting, limb weakness). Common sites of spread include the brain, bone, adrenal glands, opposite lung, liver, pericardium and kidneys. About 10% of people with lung cancer do not have symptoms at diagnosis; these cancers are incidentally found on routine chest radiography.

C. Stages of Lung Cancer

Stage 1 is when the tumor is in a single lung, and has not spread to any lymph nodes or distant organs.

Stage 2 means that cancer has spread to the lymph nodes inside the lung, but has not spread to any distant organs.

Stage 3 is diagnosed when cancer has spread to lymph nodes at the center of the chest, but has not spread to any distant organs.

In **stage 3a**, cancer has not spread to the opposite side of the body.

In **stage 3b**, it has spread to lymph nodes in the opposite lung, and has progressed above the collar bone to the throat and neck.

Stage 4 is diagnosed when cancer has spread throughout the body.

Outlooks for these stages are usually given as the percentage of people still living 5 years after their diagnosis. The following rates are from a 2015 review article in Biochemical Biophysical Acta:

Stage 1: 60-80 percent.

Stage 2: 30-50 percent.

Operable stage 3a: 10-15 percent.

Inoperable stage 3a: 2-5 percent.

Stage 3b: 3-7 percent.

D. Objective

To detect the lung carcinoma using a better medical imaging technique named marker controlled watershed segmentation.

II. MATERIALS AND METHODOLOGY

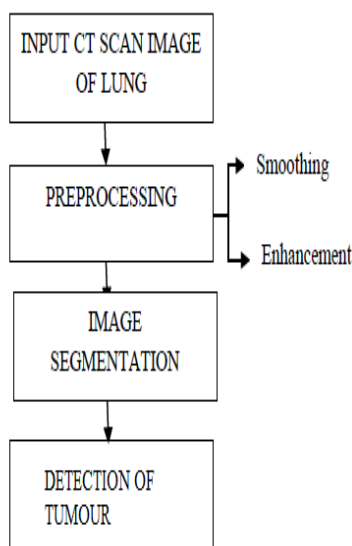


Fig. 1 Block diagram of proposed work

Lung cancer detection system using medical images follows the following stages. The system mainly consist of five sections those are listed as below,

1. Image Acquisition.
2. Image Pre-processing.
3. Image Segmentation.
4. Detection of Tumour

A. Image Acquisition

Image acquisition is the first process. CT images are well preferred as offers visualization of low contrast or small volume nodules by diminishing the slice thickness. Lung CT images can be acquired from publicly available databases namely Early Lung Cancer Action Program (ELCAP), Lung Image Database Consortium (LIDC) or Medical Image Database.

B. Image Pre - Processing

The aim of this process is an improvement of the image data that suppresses unwanted distortions or enhances some features important for further processing. With CT images, they already contain lesser amount of noise. But for getting more accurate result we will pre-process the image with help of filters [4]. The following two process are used for image pre-processing,

- a) *Image Smoothing*
- b) *Image Enhancement*

Image smoothing basically suppresses the noise or other small fluctuations in the image while enhancement technique is used to improve the interpretability or perception of information in images for human viewers, or to provide better input for other automated image processing techniques [5].

C. 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 [2]. It is an important process for most image analysis following techniques. There are various methods available for image segmentation. But Marker Controlled Watershed Segmentation is considered due to its major advantages. The marker controlled watershed segmentation is an modification for the watershed segmentation [6].

D. Detection of Tumor

After segmentation process a segmented image output with markers over it can be obtained. These markers enable us to identify the presence of the cancerous cells in lungs [3]. It also enables us to find the area where cancerous are mostly located. In this way the lung carcinoma can be detected using the marker controlled watershed segmentation of a lung CT image. And also depending on the area of the carcinoma the stage of cancer can be detected [10].

III. RESULTS AND DISCUSSION

A. Step Wise Results

Image used to detect tumor



Fig.2 Image under test

The CT image of the lung as shown in Fig.2 is kept under the test to detect the cancerous cells and find lung carcinoma.

STEP 1: Read in the image and convert it to grayscale.

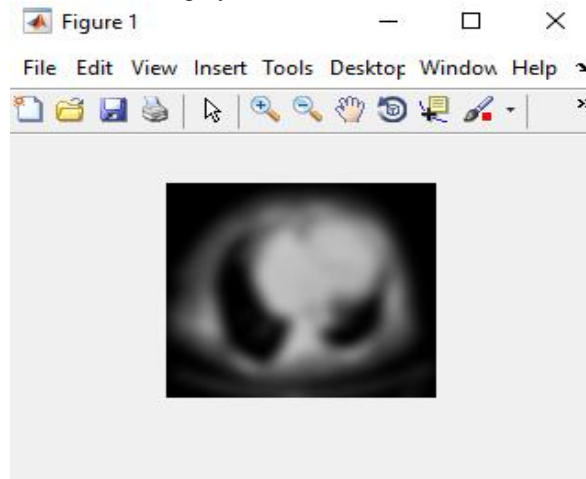


Fig.3 Grayscale image of the input image

The CT image is then converted into gray scale image as shown in Fig.3 after applying the Gaussian filter to smooth the input image by selecting appropriate blur value.

STEP 2: Use the gradient magnitude as the segmentation function. Compute the gradient magnitude. The gradient is high at the borders of the objects and low (mostly) inside the objects. The gradient image is shown in Fig.4

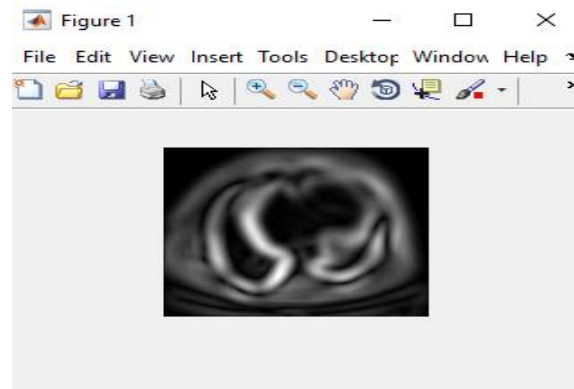


Fig.4. Gradient image

STEP 3: Watershed segmentation of gradient image.

Directly applying watershed segmentation to the gradient image shown in image Fig.5 leads to over-segmentation which is the major disadvantage of the watershed transformation which made us to use marker controlled watershed transform. The over-segmented image is shown in Fig.6.

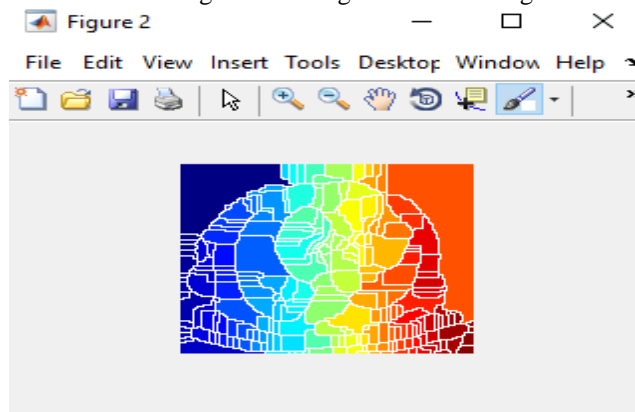


Fig.5. Over segmented image

STEP 4: Mark foreground objects.

A variety of procedures could be applied here to find the foreground markers, which must be connected blobs of pixels inside each of the foreground objects. In this example you'll use morphological techniques called "opening-by-reconstruction" and "closing-by-reconstruction" to "clean" up the image. These operations will create flat maxima inside each object that can be located using `imregionalmax`.

Opening is erosion followed by dilation, while opening-by-reconstruction is erosion followed by a morphological reconstruction. Let's compare the two. First, compute the opening using `imopen`. Next compute the opening-by-reconstruction using `imerode` and `imreconstruct`. Following the opening with a closing can remove the dark spots and stem marks. Compare a regular morphological closing with a closing-by-reconstruction. Now use `imdilate` followed by `imreconstruct`. Notice you must complement the image inputs and output of `imreconstruct`.the final image after opening and closing by reconstruction is shown in Fig.6 and Fig.7.

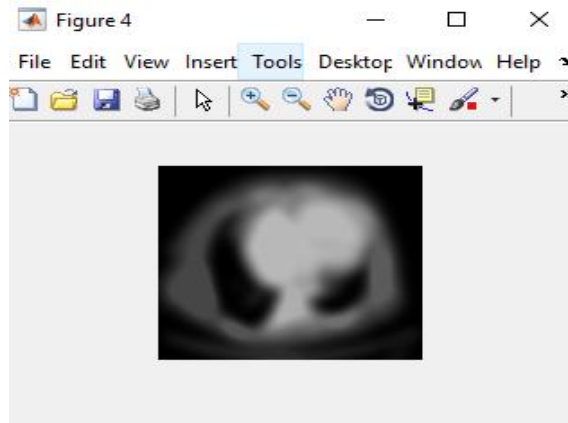


Fig.6. Image after opening by reconstruction.

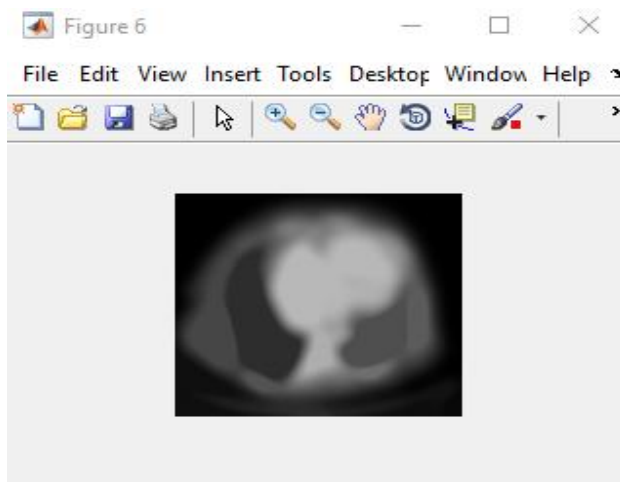


Fig.7. Image after closing by reconstruction

STEP 5: Regional maxima after opening and closing by reconstruction.

Reconstruction-based opening and closing are more effective than standard opening and closing at removing small blemishes without affecting the overall shapes of the objects. Calculate the regional maxima as shown in Fig.8 of `Iobrcbr` to obtain good foreground markers.

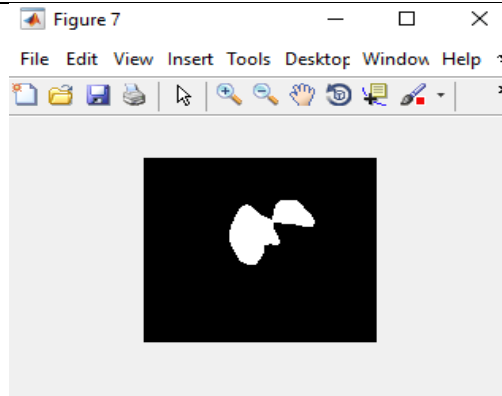


Fig.8 Regional maxima

STEP 6: Compute the Watershed Transform.

The function `imimposemin` can be used to modify an image so that it has regional minima only in certain desired locations. Here you can use `imimposemin` to modify the gradient magnitude image so that its only regional minima occur at foreground and background marker pixels. Another useful visualization technique is to display the label matrix as a color image. Label matrices, such as those produced by `watershed` and `bwlabel`, can be converted to true color images for visualization purposes by using `label2rgb`. The watershed results in new image as shown in Fig.8

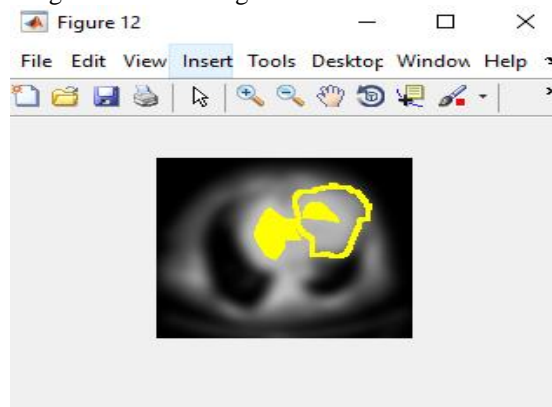


Fig.9 Watershed segmented image with true color technique

STEP 7: Colored labels superimposed transparently on original image.

We can use transparency to superimpose this pseudo-color label matrix on top of the original intensity image. The transparent label that to be merged on original image is shown in Fig.9 and the final marker based segmented image is shown in Fig.10.

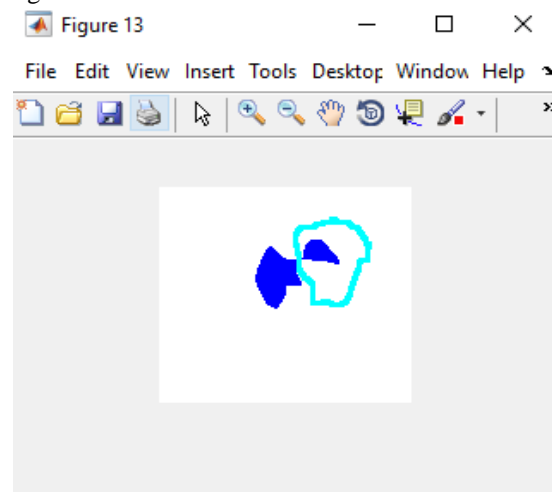


Fig.11.Transparent label.

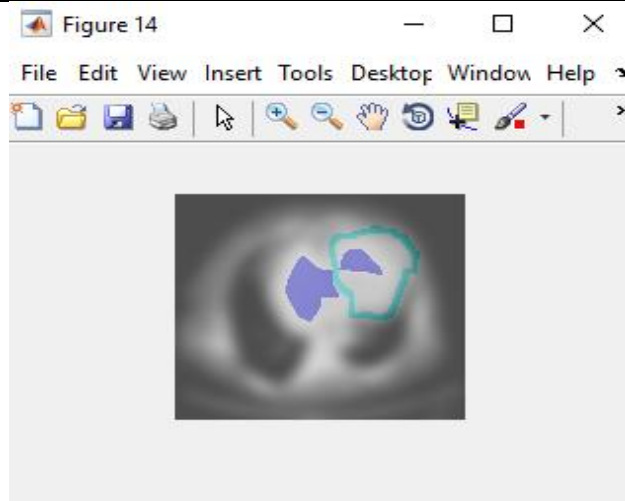


Fig.12.Final marker based segmented image.

The Fig.12 shows the presence of the lung carcinoma. Hence we can make sure the taken CT image contains the lung carcinoma.

IV. CONCLUSION

The system consists of pre-processing, segmentation and tumor detection. 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 any other technique. It gives best recognizable proof of the primary edge of the picture and furthermore maintains a strategic distance from over division. So it is efficient for segmentation. The proposed technique gives very promising results compared with other used techniques. As this paper deals with only lung carcinoma it can be extended to detect the features and extract them, and also used to classify the various stages of lung cancer using k means clustering method.

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