Diagnosis Of Lung Infection In CT ImagesUsing Image Processing

Dr. B. SUBRAHMANYESWARA RAO[1], Mr. Jarugu Charan Sudheer [2], Mr. Bupathi Jinendranath [3]

[1]Professor, Swarnandhra College of Engineering and Technology, Narsapur
ecehod@swarnandhra.ac.in

Abstract—

Now a day image processing techniques are commonly used in the medical field for early detection of lung infection. Among all different types of infections, lung infection is the most prevalent infection having the highest mortality rate. Computed tomography scans are used for identification of lung infection as it provides detailed picture of tumor in the body and tracks its growth. Although CT is preferred over other imaging modalities, visual interpretation of these CT scan images may be an error prone task and can cause delay in lung infection detection. Therefore, image processing techniques are used widely in medical fields for early stage detection of lung tumor. This paper presents an automated approach for detection of lunginfection in CT scan images. The algorithm for lung infection detection is proposed using methods such as median filtering for image preprocessing followed by segmentation of lung region of interest using mathematical morphological operations. Geometrical features are computed from the extracted region of interest and used to classify CT scan images into normal and abnormal by using support vector machine.

Key words

Image Processing, , CT scan, Tomography scan, Segmentation and Morphological operations

INTRODUCTION

The mortality rate of lung infection is the highest among all other types of infections. Lung cancer is one of the most serious cancers in the world. Lung cancer can be divided into two main groups, non-small cell lung cancer and small cell lung cancer. These assigned of the lung cancer types are depends on their cellular characteristics. As for the stages, in general there are four stages of lung cancer; I through IV. Staging is based on tumor size and tumor and lymph node location. Presently, CT are said to be more effective than plain chest x-ray in detecting and diagnosing the lung cancer. The earlier the detection is, the higher the chances of successful treatment. An estimated 85% of lung cancer cases in males and 75% in females are caused by cigarette smoking.

WORK IN RELATION

CT scan images:

A CT scan or computed tomography scan makes use of computer-processed combinations of many X-ray measurements taken from different angles to produce cross- sectional images of specific areas of a scanned object, allowing the user to see inside the object without cutting.

CT scans provide far more detailed images than conventional X-ray imaging, especially in the case of blood vessels and soft tissue such as internal organs and muscles. A part of the energy of the X-ray beam is absorbed when it passes through the body[1]. This process is described as the attenuation of the X-ray beam. Just as with an X-ray film, this attenuation depends on the tissue. Bone appears white since the attenuation of bone is very high. For air the opposite is true, so air appears black.

Fig. 1: Modern CT scans provide verydetailed images

for example of blood vessels and internal organs, by using relatively low radiation doses. This CT scan of the whole thorax and abdomen was performed in less than 1 sec with only 20 mL of contrast media, and radiation dose of 2.32 mSv With modern CT scans, you can even apply color coding to the dataset as seen in Figure 1. Scans can be completed in seconds or even fractions of a second[2]. For some CT scans, a special contrast agent is injected into a vein before the scan as this allows further assessment of the organs and vessels. These preparations for the examination may require additional time. A CT scanner can image any part of the body including the heart, lungs and abdomen. CT scans arealso invaluable in assessing skeletal injuries, as even very tiny bones are shown clearly. During the scan, the patient lies on a table that is moved through the ring-shaped gantry of the CT scanner for the examination. CT scanning is not painful and is safe for people with pacemakers. The organs and vessels[3]. These preparations for the examination may require additional time. A CT scanner can image any part of the body including the heart, lungs and abdomen. CT scans arealso invaluable in assessing skeletal injuries, as even very tiny bones are shown clearly. During the scan, the patient lies on a table that is moved through the ring-shaped gantry of the CT scanner for the examination. CT scanning is not painful and is safe for people with pacemakers[4].

CT scans are valuable in emergencies because they are able to provide information very quickly. This is important, for example when assessing strokes, brain injuries, heart disease, and internal injuries. In addition, the short duration of the scanning process benefits patients who are not easily able to keep still, such as children[6]. CT imaging is a very important tool to diagnose cancer and to obtain additional information for different clinical questions. A CT scan usually requires a higher radiation exposure dose than a conventional radiography examination[8]. However, a CT scan delivers more detailed information. Doctors and manufacturers do all they can to minimize radiation dose. As with conventional X-ray imaging, CT scans are not recommended for pregnant women unless the examination is absolutely necessary.

How is CT used in cancer:

CT is used in cancer in many different ways:

- To screen for cancer
- To help diagnose the presence of a tumor
- To provide information about the stage of a cancer
- To determine exactly where to perform (i.e., guide) a biopsy procedure
- To guide certain local treatments, such as cry therapy, radiofrequency ablation, and theimplantation of radioactive seeds
- To help plan external-beam radiation therapy or surgery
- To determine whether a cancer is responding to treatment

How Do CT Scans Work?

They use a narrow X-ray beam that circles around one part of your body. This provides a series of images from many different angles. A computer uses this information to create a cross- sectional picture. Like one piece in a loaf of bread, this two-dimensional (2D) scan shows a “slice” ofthe inside of your body[10]. This process is repeated to produce a number of slices. The computer stacks these scans oneon top of the other to create a detailed image of your organs, bones, or blood vessels. For example, asurgeon may use this type of scan to look at all sides ofa tumor to prepare for an operation.

What Is It Used For?

Doctorsorder CT scans for a long list of reasons:

- CT scans can detect bone and joint problems, like complex bone fractures and tumors.
- If you have a condition like cancer, heart disease, emphysema, or liver masses, CT scans canspot it or help doctors see any changes.
- They show internal injuries and bleeding, such as those caused bya car accident.
- They can help locate a tumor, blood clot, excess fluid, or infection.
- Doctors use them to guide treatment plans and procedures, such as biopsies, surgeries,and radiation therapy.
- Doctors can compare CT scans to find out if certain treatments are working. For example,scans of a tumor over time can show whether it's responding to chemotherapy or radiation.
- CT versus MRI

The main differences between CT and MRI are:

A CT scan uses X-rays, but an MRI uses magnets and radio waves.Unlike an MRI, a CT scan does not show tendons and ligaments.MRI is better for examining the spinal cord.A CT scan is better suited to cancer, pneumonia, abnormal chest x-rays, bleeding in the brain, specially after an injury. A brain tumor is more clearly visible on MRI[12].A CT scan shows organ tear and organ injury more quickly, so it may be more suitable for trauma cases. Broken bones and vertebrae are more clearly visible on a CT scan. CT scans provide a better image of the lungs and organs in the chest cavity between the lungs.

Lung cancer:

Lung cancer is a type of cancer that begins in the lungs. Your lungs are two spongy organs in your chest that take in oxygen when you inhale and release carbon dioxide when you exhale[13]. Lung cancer is the leading cause of cancer deaths in the United States, among both men and women. Lung cancer claims more lives each year than do colon, prostate, ovarian and breast cancers combined.

Lung cancer staging depends on spread of cancer in the lungs and tumor size. Lung cancer is mainly classified into 4 stages in order of seriousness:

Stage I-Cancer is confined to the lung,

Stage II and III-Cancer is confined within the chest and

Stage IV-Lung cancer has spread from the chest to other parts of the body. Lung cancer diagnosis can be done by using various imaging modalities such Positron Emission Tomography (PET), Magnetic Resonance Imaging (MRI), Computed Tomography (CT) and Chest X-rays. CTscan images are mostly preferred over other modalities because they are more reliable, have better clarity and less distortion[15]. Visual interpretation of database is a tedious procedure that is time consuming and highly dependent on given individual. This introduces high possibility of human errors and can lead to misclassification of cancer. Hence an automated system is of utmost importance to guide the radiologist in proper diagnosis of lung cancer.

Symptoms

Lung cancer typically doesn't cause signs and symptoms in its earliest stages. Signs and symptoms of lung cancer typically occur only when the disease is advanced.

Signs and symptoms of lung cancer may include:

- A new cough that doesn't go away
- Coughing up blood, even a small amount
- Shortness of breath
- Hoarseness
- Losing weight without trying
- Bone pain
- Headache

Stages of lung cancer

Cancer stages tell how far the cancer has spread and help guide treatment.The chance of successful or curative treatment is much higher when lung cancer is diagnosed and treated in the early stages, before it spreads. Because lung cancer doesn't cause obvious symptoms in the earlier stages, diagnosis often comes after it has spread.

Non-small cell lung cancer has four main stages:

Stage 1: Cancer is found in the lung, but it has not spread outside the lung.

Stage 2: Cancer is found in the lung and nearby lymph nodes.

Stage 3: Cancer is in the lung and lymph nodes in the middle of the chest.

Stage 3A: Cancer is found in lymph nodes, but only on the same side of the chest where cancer first started growing.

Stage 3B: Cancer has spread to lymph nodes on the opposite side of the chest or to lymph nodes above the collarbone.

Stage 4: Cancer has spread to both lungs, into the area around the lungs, or to distantorgans.

Treatment for non-small cell lung cancer (NSCLC) varies from person to person. Much dependson specific details of your health.

Stage 1 NSCLC: Surgery to remove a portion of the lung may be all you need. Chemotherapymay also be recommended, especially if you're at high risk of recurrence.

Stage 2 NSCLC: You may need surgery to remove part or all of your lung. Chemotherapy isusually recommended.

Stage 3 NSCLC: You may require a combination of chemotherapy, surgery, and radiation treatment.

Stage 4 NSCLC is particularly hard to cure. Options include surgery, radiation, chemotherapy, targeted therapy, and immunotherapy.

EXISTING METHODS

There are two existing methods for detection of lung infection.They are

1. **Manual detection of Lung infection**
2. **Use of basic thresholding techniques for lung infection detection and for classification**

Manual detection of Lung infection:

- Manual detection means Doctor examines a patient for lung infection(X-rays or CT scanreports).
- Doctor has to write a diagnosis(in most cases on paper).
- It is completely based on doctors experience (experts).

THRESHOLDING TECHNIQUE:

- Thresholding is a type of image segmentataion , where we change the pixels of an image tomake the image easier to analyze.

- In thresholding, we convert an image from colour or grayscale into a binary image, i.e ,onethat simply black and white.

PROPOSED METHODS

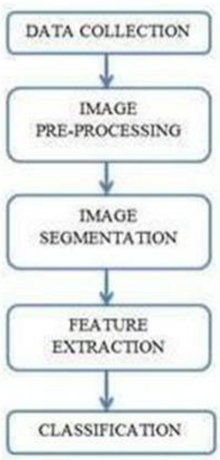


Fig. 1. Block diagram of the proposed system

The proposed system for lung cancer detection in CT images is shown with the help of a flowchart in figure 1.The methodology is carried out in five main steps and each step of this system is discussed in detail in section below.

Data Collection

The first step is to obtain lung CT images of cancer patients. For research work, the images have been downloaded from the Cancer Imaging Archive database. The images are stored in DICOM format. The image database contains Computed Tomography images of patients with and without lung cancer.

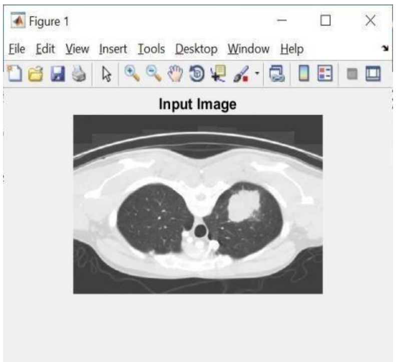


Image Pre-Processing

The objective of image preprocessing stage is to suppress unwanted distortions present in the image and to enhance some features useful for further processing. It includes two main steps such as image smoothing and image enhancement. Image smoothing is done to remove unwantednoise present in the image. CT scan images are prone to salt and pepper noise, hence median filtering is found to be quite effective technique in eliminating this impulse noise while preserving the edges. Median filtering gives the best results for image smoothing as it removes noise without blurring the image.

Image enhancement technique improves the quality of digital images to produce better output for further processing. Contrast adjustment is done to enhance the image since image quality is affected by artifacts caused due contrast variations in the image. Contrast adjustment enhances the contrast of an image by transforming input pixel values to new values such that by default 1% data gets saturated at low and high intensity of input image data.

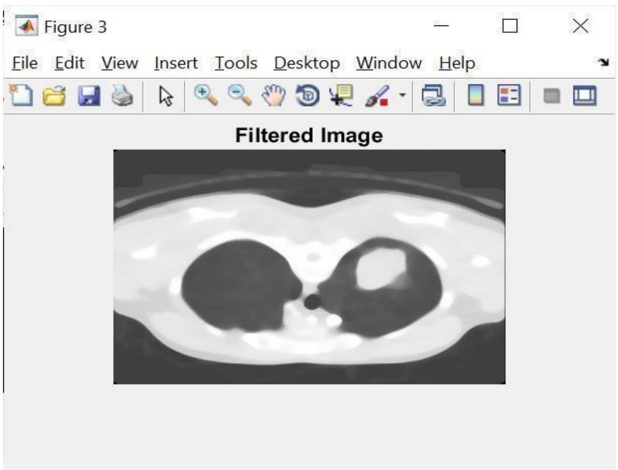
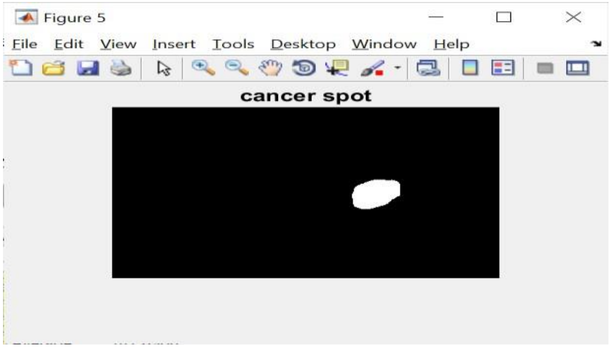


Image Segmentation

The process of separating out required region of interest from the image is known as segmentation. Mathematical morphological operations are powerful tools in acquiring lung region from binary images. In our methodology, first the preprocessed gray scale images were converted to binary images. Morphological opening operation was performed to the binary image with disk structuring element for removal of unwanted components from the image. The opened image was then complemented and clear border operation was performed to it. The lung masks were obtained by filling the holes and gaps present in the lungs. Finally exclusive OR operation was performed to lung mask output and clear border output to give us the segmented tumor region.



Feature Extraction

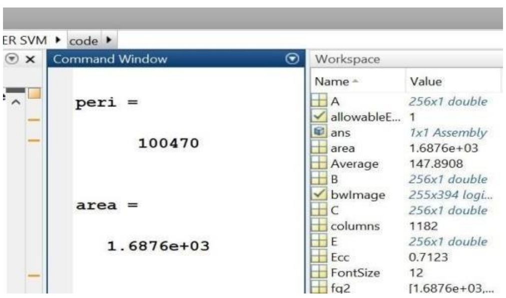
Feature extraction is the most essential step that transforms input data into required features. This stage extracts out significant features of segmented region of interest and these features serve as input for classification of CT scan images. The size and shape of tumor present in the lungs is estimated by extracting three geometrical features. The features are area, perimeter and eccentricity of cancerous lung nodule.

Area: This is a scalar quantity which gives total number of pixels acquired by cancerous lung nodule. The area is evaluated from the binary image by taking summation of pixel areas in the image that are registered with value 1.

Perimeter: This is a scalar quantity that gives the total pixels present at the border of the lung tumor. The perimeter is evaluated from the binary image by summing the pixels registered with value 1, at the outline of lung nodule.

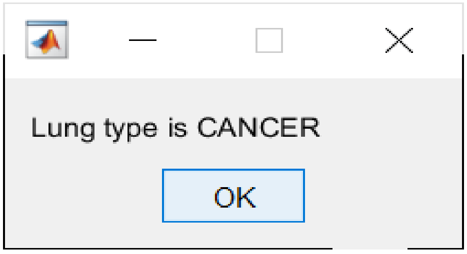
Eccentricity: This metric value is also referred to irregularity index (I) or circularity or roundness. For a circular shape eccentricity value is equal 1 and the value is less than 1 for any other shape.

Eccentricity =length of major axis /length of minor axis



Classification

The Classification stage involves labeling the CT scan images as normal and abnormal. In our method SVM algorithm will be used for detection of lung cancer in CT images. SVM classifiers are supervised learning models that analyze input data and classify them according to pattern. The SVM classifier builds a model by using training dataset and categorizes it into two classes. The SVM algorithm then assigns new examples of testing dataset to one of the two classes. SVM classifier thus finds the best hyper plane that separates the two groups and thus classifies the lung CT images. For the best hyper plane data points of one class are separated from the other by largest margin between the two classes.



PERFORMANCE EVALUATION AND RESULTS

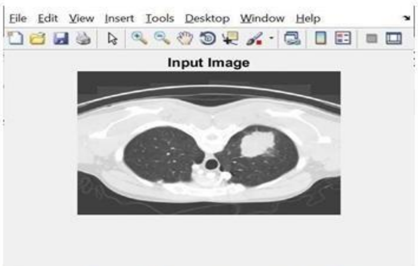
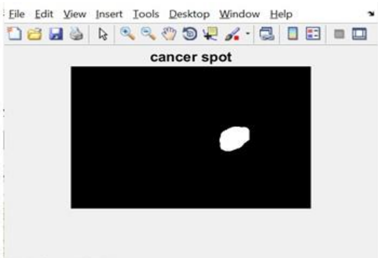


Fig.2 Selected Input image (CT lung cancer)

Fig. 3 Preprocessed Image



Fig,4: Segmented Cancerous Part from CT Image

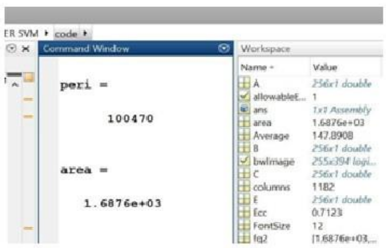


Fig.5: Feature Extraction from ROI(cancerus part):(area and perimeter)

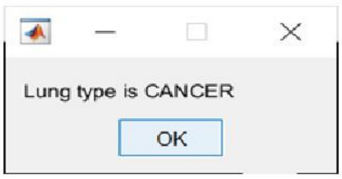


Fig.6:Classified Output

Conclusion

Lung cancer is the most dangerous and widespread in the world according to stage the discovery of the cancer cells in the lungs, this gives us the indication that the process of detection this disease plays a very important and essential role to avoid serious stages and to reduce its percentage distribution in the world. To obtain more accurate results we divided our work into three stages: Image Enhancement stage, Image Segmentation stage and Features Extraction stage. Lung Nodule Detection in CT Scans is an active area of research which is continuously emerging and there are many enhancements that can be included to make more efficient.

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