

LUNG CANCER DETECTION USING MORPHOLOGICAL WATERSHED OPERATIONS

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Abstract – Cancer is one of the most serious and widespread disease across the world accounting for a large number of deaths every year. Lung cancer is the leading cause of cancer deaths in the world, having high mortality rate. The main problem in lung cancer is that most of these cases are diagnosed at the later stages of cancer, making treatments more problematic and reducing the survival chances. The survival rate of Cancer patients' increment from 14-49% if the illness is recognized in time. Early discovery of lung cancer can expand the possibility of survival among individuals. A CT scan is more likely to show lung tumors than routine chest x-rays as it can show the size, shape, and position of any lung tumor and can help find enlarged lymph nodes that might contain cancer that has spread. Visual interpretation of CT scan can be difficult and error prone. Hence image processing techniques are used to detect the cancer nodules at an early stage. This paper deals with an automated approach for early detection of lung cancer. This algorithm is proposed using methods such as Median Filtering for Image Smoothing, Contrast Adjustment for enhancing the image, Segmentation using Morphological Watershed Operations and Otsu's Thresholding.

Key Words: CT, Median Filtering, Contrast Adjustment, Morphological Watershed Operations, Otsu Thresholding.

1. INTRODUCTION

Cancer is a disease in which some of the body's cells grow uncontrollably and spread to other parts of the body. Cancer can start almost anywhere in the human body, which is made up of trillions of cells. Normally, human cells grow and multiply through a process called cell division, to form new cells as the body needs them. When cells grow old or become damaged, they die, and new cells take their place. Sometimes this orderly process breaks down, and abnormal or damaged cells grow and multiply when they shouldn't. These cells may form tumors, which are lumps of tissue. Tumors can be cancerous or not cancerous (benign). Cancerous tumors spread into, or invade, nearby tissues and can travel to distant places in the body to form new tumors. Cancerous tumors may also be called malignant tumors. Benign tumors do not spread into, or invade, nearby tissues. When removed, benign tumors usually don't grow back, whereas cancerous tumors sometimes do. Lung cancer, also known as lung carcinoma, is a malignant lung tumor characterized by uncontrolled cell growth in tissues of the lung. The beginning of cancer is the development of abnormal cells. These abnormal cells

multiply and form cancerous tissues. Lung Cancer is divided into two major types based on the appearance of lung cancer cells under the microscope. They are non-small cell lung cancers and small scale lung cancers.

With respect to the stages, there are four phases of lung cancer- I to IV. Arranging depends on tumor size and tumor lymph node location. CT scan is said to be more compelling than plain chest x-rays in identifying and diagnosing the lung cancer. Earlier the detection more is the survival rate of the patient. Visual Interpretation of CT Scan is a tedious process and hence an automated approach will help to detect the cancer at an earlier stage. The methodology developed for this system includes data collection, image preprocessing, segmentation and feature extraction.

2. RELATED WORKS

A number of researches have been carried out in developing an automated lung cancer detection system.

[1] Taruna Aggarwal, Asna Furqan, Kunal Kalra – "Feature Extraction and LDA based Classification of Lung Nodules in Chest CT scan Images" 2015. Optimal thresholding and gray level characteristics used for segmentation of lung nodules from the lung volume area. After detection of lung mass tissue, geometrical features are extracted. Simple image processing techniques like filtering, morphological operations etc. are used on CT images.

[2] Shubhangi Khobragade, Aditya Tiwari, C.Y. Patil, Vikram Narke – "Automatic Detection of Major Lung Diseases Using Chest Radiographs and Classification by Feed-forward Artificial Neural Network" 2016. This paper presents an automated system for detection of three lung diseases namely tuberculosis, lung cancer and pneumonia. Chest X-ray images are pre-processed by using methods such as histogram equalization for image enhancement and high pass filtering technique was used for noise removal. Techniques such as intensity-based method and are used to detect lung boundaries.

[3] Sruthi Ignatious, Robin Joseph – "Computer Aided Lung Cancer Detection System" 2015. This model uses median and Gabor filter for image pre-processing followed by auto enhancement and fast Fourier technique for image enhancement. Segmentation is done using three approaches Thresholding, Watershed segmentation and Region growing segmentation. Features such as entropy, perimeter, eccentricity, mean and standard deviation are extracted.

[4] Nidhi S. Nadkarni, Sangam Borkar – "Detection of Lung Cancer in CT Images using Image Processing" 2019. This paper presents an automated approach for detection of

lung cancer in CT scan images. The algorithm for lung cancer detection is proposed using methods such as median filtering for image pre-processing 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 SVM. **METHODOLOGY**

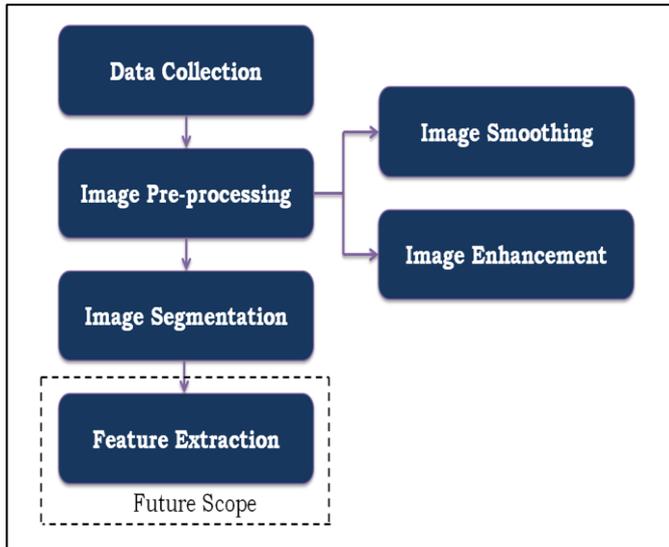


Fig-1: FlowChart

2.1 Data Collection

It is the systematic approach to gathering and measuring information from a variety of sources to get a complete and accurate picture of an area of interest. Our data collection process involves collection of Computed Tomography images. These images are obtained from the TCIA (The Cancer Imaging Archive) and are stored in DICOM (Digital Imaging and Communications in Medicine) format. This database contains the Computed Tomography Images of patients with or without lung cancer.



Fig-2: A Typical CT Scan

2.2 Image Pre-processing

Image Pre-processing is done to improve the image data and to suppress unwilling distortions and noise present in the image, it also enhances some features of the image that are required for the further processing.

In our design the pre-processing is carried out in two different sections, **Image Smoothing** and **Image Enhancement**. Image Smoothing is done to remove unwanted noise present in an image. **Image Enhancement** is a process which improves the quality and information content of the digital image to provide

better output for further processing. **Median filtering** and **Contrast adjustment** techniques are used for Image Pre-processing.

The median filter is a non-linear digital filtering technique, often used to remove noise from an image or signal. The main idea of the median filter is to run through the signal entry by entry, replacing each entry with the median of neighboring entries. Image Enhancement is a process which improves the quality and information content of the digital image to provide better output for further processing. The goal of enhancement techniques is to accentuate certain image features and to improve the interpretability of information in images for analysis and display.

$B = \text{medfilt2}(A, [m \ n])$ - Median Filter Operation

$J = \text{imadjust}(I)$ - Contrast Adjustment

2.3 Image Segmentation

It is the process of separating out required region of interest from the image by dividing the image into different regions based on the characteristics of pixels for efficient analysis. Image segmentation is typically used to locate objects and boundaries in images. The goal of segmentation is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze. We use Morphological Watershed Operations for image segmentation. Segmentation involves various processes. In our design segmentation is carried out at various levels.

A. Edge Detection - It is a method of segmenting an image into regions of discontinuity. It is a technique of image processing used to identify points in a digital image with discontinuities, simply to say, sharp changes in the image brightness. In our design the Edge detection is carried out using Sobel Filter.

B. Morphological Operations - Morphology is a collection of non-linear operations related to the shape or morphology of features in an image. Morphological operations rely only on the relative ordering of pixel values, not on their numerical values, and therefore are especially suited to the processing of binary images. A morphological operation on a binary image creates a new binary image in which the pixel has a non-zero value only if the test is successful at that location in the input image.

C. Image Thresholding - Image thresholding is a simple, yet effective, way of partitioning an image into a foreground and background. This is a method that creates a bitonal (aka binary) image based on setting a threshold value on the pixel intensity of the original image. In our design we use Otsu's method for thresholding.

D. Region of Interest - A region of interest (ROI) is a portion of an image that you want to filter or operate on in some way. A common use of an ROI is to create a binary mask image. In the mask image, pixels that belong to the ROI are set to 1 and pixels outside the ROI are set to 0. In general words, a region of interest (often abbreviated ROI),

are samples within a data set identified for a particular purpose.

E. Watershed Transformation - Watershed segmentation is another region-based method that has its origins in mathematical morphology. Watershed segmentation is a region-based technique that utilizes image morphology. It requires selection of at least one marker ("seed" point) interior to each object of the image, including the background as a separate object followed by the identification of watershed ridge lines we perform the impose minima function. This function modifies the gray scale mask image using morphological reconstruction so it only has regional minima wherever binary marker image is nonzero.

3.4 Feature Extraction

We have added a fourth stage in our methodology that is mainly intended for the future scope of our project. This fourth stage is the feature extraction. A feature is a significant piece of information extracted from an image which provides more detailed understanding of that image.

This stage extracts significant features of segmented region of interest. The size and shape of tumour present in the lungs are estimated by extracting geometrical features and intensity based features. The Grey Level Co-Occurrence matrix is used for the texture analysis of the image. It is a statistical method that characterizes the texture of an image by calculating how often pairs of pixel with specific values and in a specified spatial relationship occur in an image, and then extracts statistical measures from this matrix.

3. RESULTS

This project uses Matlab a programming and numeric computing platform, for its design and development.

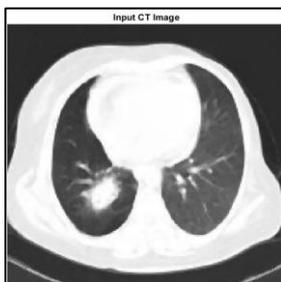


Fig-3: Cancerous Lung Image

First we convert the input CT image into a gray level image; the reason behind this conversion is that less information needs to be provided for each pixel present in the image. This operation is carried out using '**rgb2gray()**' function. The CT Scans are prone to salt and pepper noise and we are removing it with the help of median filtering technique.

Then we are adjusting the histogram of the image with the help of Contrast Adjustment technique. Since we are dealing with medical images Contrast Adjustment is the

most efficient compared to other existing techniques.

B = medfilt2(A,[m n]) - Median Filter Operation

J = imadjust(I) - Contrast Adjustment Operation

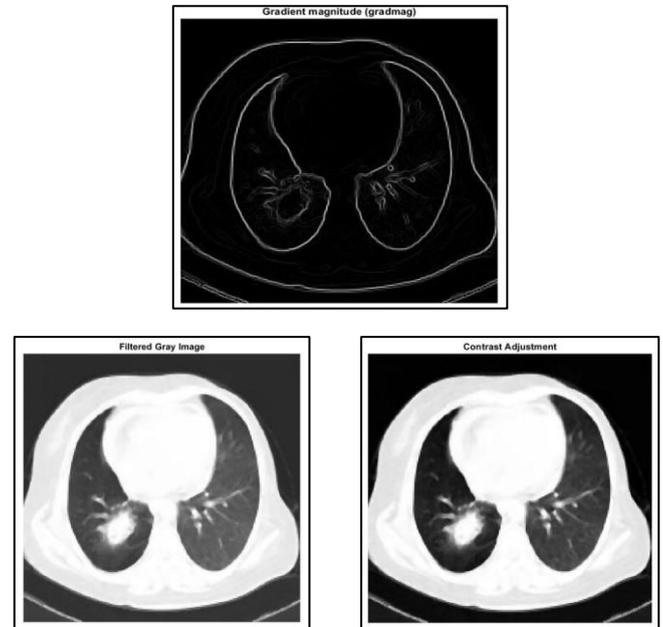


Fig-4: Pre-processed Image

Under segmentation we are separating out required region of interest from the image by dividing the image into different regions based on the characteristics of pixels for efficient analysis. This is done at various levels starting from Edge Detection. We've used Sobel Filter for Edge Detection in our design, which is done using the command **h=fspecial('sobel')**. After finding the sobel operator, the gradient of the image is found using the following command, **gradmag = sqrt(Ix.^2 + Iy.^2)**.

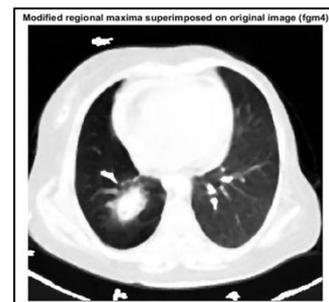


Fig-5: Edge Detected Image

The edge detected image is then subjected to multiple processes of Morphological operations. These include Dilation, Erosion, Opening, Closing and Morphological reconstruction. During Dilation operation, the value of the output pixel is the maximum value of all pixels in the neighborhood. During Erosion operation, the value of the

output pixel is the minimum value of all pixels in the neighborhood.

Morphological opening of an image is erosion followed by dilation. The opening operation erodes an image and then dilates the eroded image, using the same structuring element for both operations. Morphological reconstruction can be thought of conceptually as repeated dilations of an image. In morphological reconstruction, the peaks in the image “spread out,” or dilate. The closing operation dilates an image and then erodes the dilated image, using the same structuring element for both operations. Morphological closing is useful for filling small holes from an image while preserving the shape and size of the objects in the image. We again perform morphological reconstruction on this obtained image.

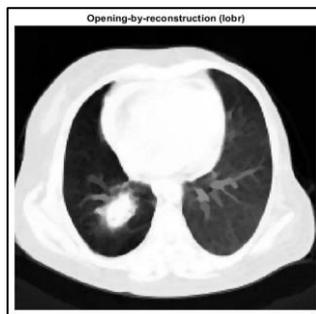


Fig-6: Opening and Closing by reconstruction

Next step deals with the computing of the regional maxima of the image. Regional maxima are connected components of pixels with a constant intensity value, surrounded by pixels with a lower value.

This is done by the following operation –

$$BW = \text{imregionalmax}(I).$$

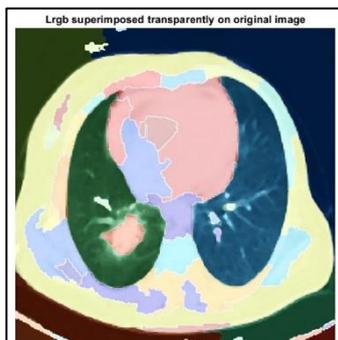


Fig-7: Regional Maxima superimposed on image

We then perform image thresholding operation. The main objective of thresholding is making the image easier to analyse. We use Otsu’s method to perform thresholding. Otsu’s method is an adaptive thresholding way for binarization in image processing. Otsu’s thresholding method involves iterating through all the possible threshold values and calculating a measure of spread for the pixel levels each side of the threshold by going through all possible threshold values from 0 to 255, i.e. the pixels that

either falls in foreground or background. Thresholding is done by using the following keyword **BW=imbinarize(I,method)**. A region of interest (ROI) is a portion of an image that you want to filter or operate on in some way. A common use of an ROI is to create a binary mask image. In the mask image, pixels that belong to the ROI are set to 1 and pixels outside the ROI are set to 0. In general words, a region of interest are samples within a data set identified for a particular purpose.

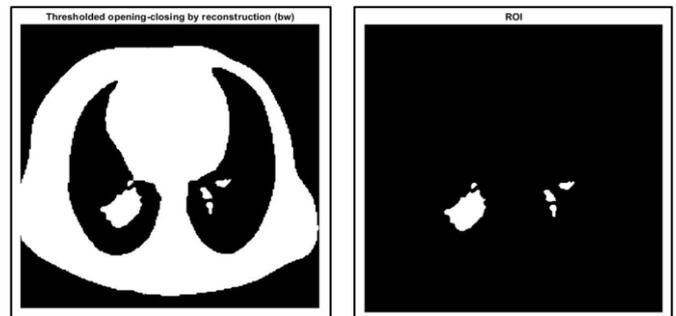


Fig-8: Thresholded Image & ROI

Segmentation using the watershed transform works well if you can “identify”, or “mark, foreground objects and background locations. We use Marker Controlled Watershed Segmentation.

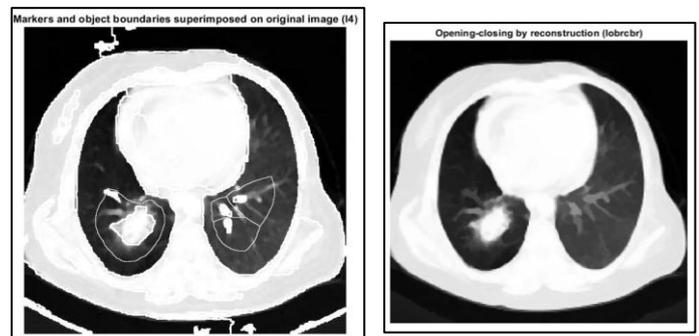
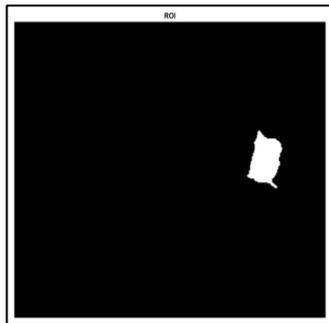
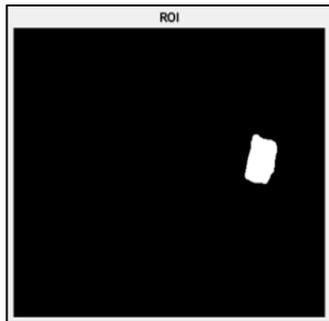


Fig-9: Marker controlled Watershed Segmentation

The watershed segmented image is converted into a RGB image to analyze the various cancerous nodules which are highlighted and the region of its presence is observed.

4. OBSERVATIONS

The above image is taken as an input to analyze and compare the results produced by the previous best model and our proposed model. The current best model was proposed by Nidhi S. Nadkarni, Sangam Borkar – “Detection of Lung Cancer in CT Images using Image Processing” 2019.



Current Model



Proposed Model

From the above figures we can observe the differences in the region of interest of the previous models and our current model. The region of interest is the most important aspect of our process because it determines various characteristics of lung nodules and it is the basis from which the features are calculated. These extracted features are the basic building blocks for the classification models; hence accuracy in region of interest is a basic need of the hour. The region of interest in the current method is more accurate comparatively. So this helps us to extract features more efficiently and effectively. Hence our proposed method is more efficient in detection of lung nodules than the existing models.

This increase in efficiency is because of the updated and more steps added when compared to the previous models. Most of the previous methods use only morphological operations in segmentation but we are adding edge detection using sobel filter which increases the accuracy of the system followed by watershed segmentation and adaptive thresholding. The addition of a feature extraction step which is mainly intended for future scope is an add-on for further classification. The features are extracted using GLCM, which is the best technique for extraction of features. Hence the proposed model offers much better results when compared with the existing model.

5. FUTURE SCOPE

We have added a fourth stage in our methodology that is mainly intended for the future scope of our project. This fourth stage is the feature extraction. This stage extracts significant features of segmented region of interest. The size and shape of tumor present in the lungs are estimated by extracting geometrical features and intensity based features. The GLCM functions works by finding the texture of a specific image by calculating how frequently pairs of pixel with specific intensity values and in a specified spatial relationship occur in an image, creating a GLCM, and then extracting statistical information from this matrix. The parameters extracted using GLCM for the input image which we've taken is as shown.

Contrast = 0.0844
 Variance = 0.0033
 Correlation = 0.1233
 Smoothness = 0.9584
 Energy = 0.9032
 Kurtosis = 13.7170
 Homogeneity = 0.9748
 Skewness = 0.8196
 Mean = 0.0011
 RMS = 0.0577
 Standard Deviation = 0.0577
 IDM = -0.5226
 Entropy = 2.9724

These numerical features calculated from the co-occurrence matrix can be used to represent, classify and compare textures. The same parameters can be extracted for different input CT images and can be used for further classification. A classification model need datasets of around 10,000 and above, hence this is proposed as a future scope for creating different classification models.

6. CONCLUSION

In this design, a system for automatic detection of lung cancer in CT images was successfully developed using various image processing techniques. The adopted methodology performs well in enhancing, segmenting and extracting features from CT images. Median filtering technique was effective in eliminating the noise present in the CT image. Morphological operations enable accurate segmentation of lung and tumor regions. The feature extraction was successfully done using GLCM from the Region of Interest obtained and serves as an input to Feature Classification for future scope.

Hence, this proposed methodology helps in accurate and early stage detection of lung cancer.

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