

Lung Cancer Detection on CT-Scan Images by using Artificial Neural Network

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Abstract- Throughout the world, the one of the main reason of death is lung carcinoma or lung cancer. But if it is detected in the very beginning stage then there is a high probability of survival. Survival rate of patients of lung cancer may be increases from 14% to 49% if it is detected on early stage on time. Lung cancer is detected mainly from analysis of the computed tomography (CT) scans by doctors. An effective screening test has long been required by medical experts for early stage detection of the diseases with the goal of increase in saving human lives. Hence, through CT scans, an effective lung cancer detection system scans using artificial neural networks with image processing techniques is used to classify the presence of lung cancer. Histogram equalization, image thresholding, filtering and Gray Level Co-occurrence Matrix (GLCM) technique etc. are used for feature extraction as image pre-processing techniques. In the proposed approach, the classification of cancer in CT scan images has been performed by using an artificial neural network..

Keywords– Artificial Neural Network, Histogram Equalization, Image Segmentation, Lung Cancer Detection, Thresholding

I. INTRODUCTION

Lung Cancer is considered as the main cause of cancer death worldwide, and it is difficult to detect the presence of cancerous cells in lungs at an early stage because the symptoms only appear at later stages and thus increasing the mortality rate [1]. According to the American Cancer Society, the current 5-year survival rate is around 18% which is significantly low in comparison to other cancers including breast, colon and prostate. Survival from lung cancer is directly dependent upon the cancer growth and its detection time. The timely detection of lung cancer can increase the survival rate from 14% to 49%.

There are many techniques to diagnose the presence of lung cancer such as Sputum Cytology, Magnetic Resonance Imaging (MRI), Computed Tomography (CT Scans) and Chest Radiograph (X-Ray) [2]. However, these techniques are time consuming and expensive. Further, most of the techniques are capable of detecting lung cancer at an advanced stage when the symptoms start to appear, thus increasing the mortality rate among patients. Therefore, there is a great need to a system to detect the presence of lung cancer at an early stage in order to increase the survival rate among patients [3-4]. Image processing techniques act as a good quality tool for improving the manual analysis of CT scans [5-7].

For this reason, we propose to use an automatic diagnostic system for the detecting the presence of lung cancer in its early stages based on the analysis of CT scans of the lungs. In order to obtain desired results, we have developed a preprocessing stage comprising of histogram equalization, segmentation by thresholding and image filtrations. Histogram equalization is used to increase the global contrast of an image by using its histogram [8]. Image segmentation is basically a processing of partitioning a digital image into multiple segments. Segmentation is used to simplify or change the representation of an image into something that is more meaningful and easier to analyze [1,12]. We have used the thresholding method for the purpose of segmentation. Thresholding is the simplest method of image segmentatio. From a grayscale image, thresholding can be used to create binary images [13]. Further, the thresholding function is based upon Otsu's Method which is named after Nobuyuki Otsu. It is used to automatically perform clustering based image thresholding, or reduction of a grayscale image to a binary image [14]. Image filtering is used for many applications including smoothing, sharpening, removing noise and edge detection. A filter is defined by a small array applied to each pixel and its neighbors within an image [9]. A sobel filter has been used to perform the process of filtration.

Feature extraction is done by using gray level co-occurrence matrix (GLCM) techniques [10]. In this stage, detection and isolation of desired shapes from the preprocessed image has been performed. During the last stage, classification has been done to detection the presence of lung cancer. An artificial neural network has been used for the purpose of classification.

II. METHODOLOGY

Overall, there are three main processes used throughout the report: Pre-processing, feature extraction and finally the classification process [15]. Further pre-processing has been divided into histogram equalization, segmentation by thresholding and image filtration. MATLAB is used in every process made throughout the project. Process involved in the lung cancer detection system for the project is given in Figure (2.1).

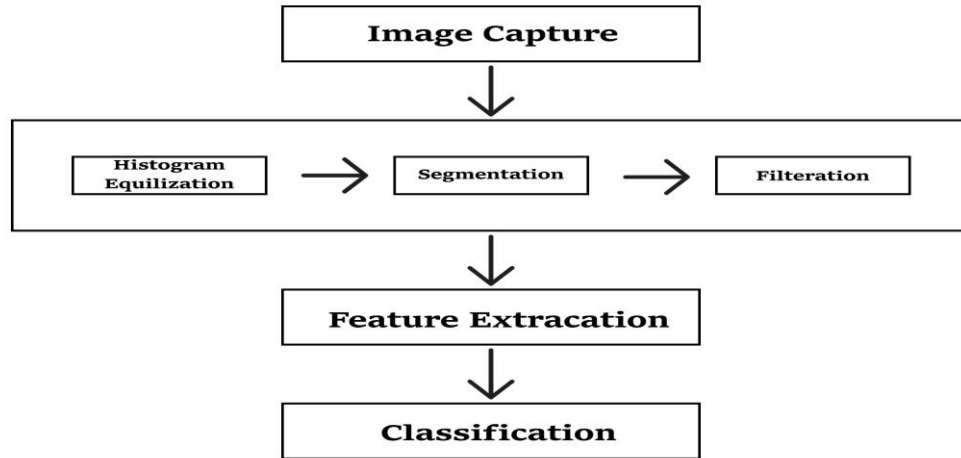


Fig. 2.1. Lung Cancer Detection System

The pre-processing is done to enhance the image contrast, remove noise and unnecessary fluctuations.

2.1 Image Acquisition

First step is to acquire the CT scan images of the lung cancer patients. The lung CT images are better as compared to X-ray and MRI as the amount of noise and fluctuations is low. The main advantage of using computed tomography is that, it gives better clarity and less distortion. For research work the CT scans are acquired from Cancer Imaging Archive and Kaggle. The format for the dataset is DICOM (Digital Imaging and Communications in Medicine). The images are in raw form i.e. lot of noise and unwanted fluctuations are observed in these images. To improve the contrast and intensity, pre-processing has been performed on these raw images.

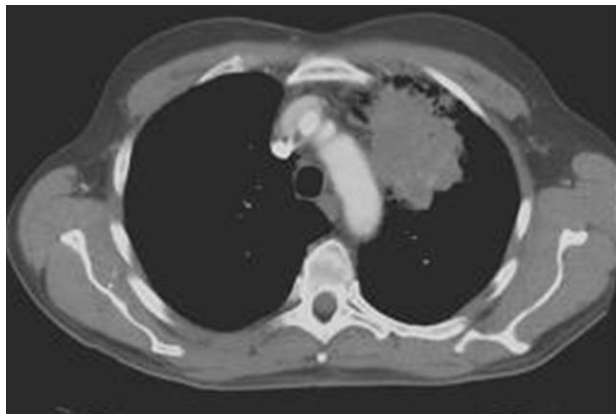


Fig. 2.2. Input CT Scan Image

III. IMAGE PRE-PROCESSING

Pre-processing is common when it comes to operations with images. Image pre-processing involves a set of functions or operations performed in order to enhance the contrast, illumination, intensity, removal of noise and edge detection. Some of the commonly used pre-processing techniques are smoothing, median filter, segmentation, dilation, background subtraction and thresholding.

In this project, a set of pre-processing techniques have been proposed which include histogram equalization, thresholding for segmentation and image filtration

The test set for this evaluation experiment watermark image randomly selected from the internet. Matlab 7.0 software platform is use to perform the experiment. The PC for experiment is equipped with an Intel P4 2.4GHz Personal laptop and 2GB memory.

The proposed scheme is tested using ordinary image processing. From the simulation of the experiment results, we can draw to the conclusion that this method is robust to many kinds of watermark images.

3.1 Histogram Equalization

This method is used to increase the global contrast of an image by using its histogram. The lower local contrast of images is adjusted by spreading out the most frequent intensity values. This method is useful when the background and foreground of the image are both either dark or light. In particular, this method is used for CT scans, X-rays and MRIs for research in the medical field.

We have used two main functions in order to implement this technique i.e. `histeq()` and `imhist()`. The function, `histeq()` accepts a grayscale image as a parameter to perform histogram equalization and the function, `imhist()` is used to display the histogram of the image.

Let I be the image represented as M_r by M_c matrix of integer pixel intensities ranging from $0 - L-1$, where, L is the number of possible intensity values. Let p denote the normalized histogram of I with a bin for each possible intensity.

$$p = \frac{\text{no. of pixels with intensity } n}{\text{total no. of pixels}}$$

where, $n = 0, 1, 2, \dots, L-1$ (255 maximum possible values)

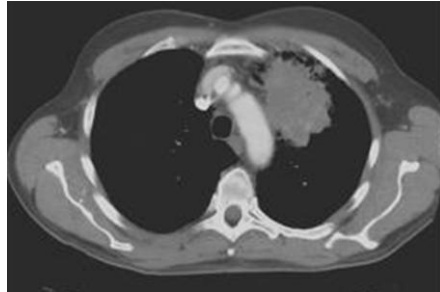


Fig. 3.1 (a) Original Image



Fig. 3.1 (b) Histogram Equalization Image

The intensity values of the image are divided into a series of intervals. The bins are usually specified as consecutive, non-overlapping intervals of a variable. The bins must be adjacent and are often of equal size. If the bins are of equal size, a rectangle is erected over the bin with height proportional to the frequency, the number of cases in each bin. Further, a histogram can also be normalized to display relative frequencies. It then shows the proportion of cases per unit of the variable on horizontal axis.

The histogram equalized image g will be defined by using the following formula,

$$g_{i,j} = \text{floor}((L-1) \sum_{n=0}^{I_{i,j}} p_n)$$

floor function rounds down the value to the nearest integer.

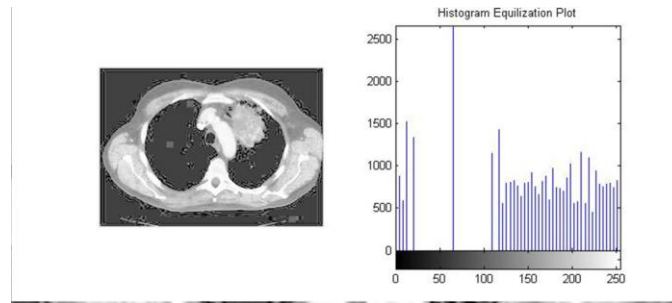


Fig. 3.2. Histogram of the Image

3.2 Segmentation

Image segmentation is a process of partitioning a digital image into multiple segments. The goal of segmentation is to simplify or change the representation of an image into something more meaningful and easier to analyze. Segmentation divides the image into its constituent regions or objects. 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.

For the purpose of segmentation, we have used the thresholding technique. Thresholding is the simplest method of image segmentation. From a grayscale image, thresholding can be used to create binary images. The function `graythresh()` is used to perform image thresholding. The `graythresh()` function computes a global threshold level, that can be used to convert an intensity image to a binary image. This function uses the Otsu's method, which chooses the threshold to minimize the interclass variable of the black and white pixels.

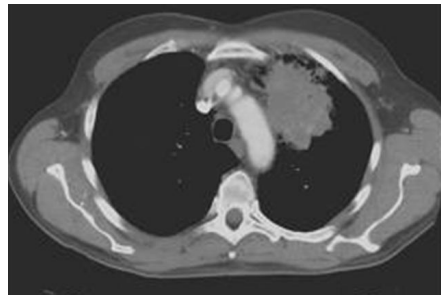


Fig. 3.3 (a) Original Image



Fig. 3.3 (b) Segmented Image

Otsu's method is named after Nobuyuki Otsu, it is used to automatically perform clustering based image thresholding, or reduction of a grayscale image to a binary image. The algorithm assumes that the image contains two classes of pixels following bimodal histogram. It then calculates the optimum threshold separating the two classes so that their combined interclass variance is minimal. We exhaustively search for the threshold that minimizes the intra-class variance defined as weighted sum of variances of the two classes.

$$\sigma^2(t) = \omega_0(t) \sigma_0^2(t) + \omega_1(t) \sigma_1^2(t)$$

In order to implement the thresholding technique, we implemented foreground markers and background markers in order to modify the segmentation function to only get the minima.

3.3 Filtration

Image filtration is used for many applications including smoothing, sharpening, removal of noise and edge detection. A filter is defined by a kernel, which is a small array applied to each pixel and its neighbors within an image. Filtering is a neighborhood operation, in which the value of any given pixel in the output image is determined by applying some algorithm to the values of the pixels in the neighborhood of the corresponding input pixel. A pixel's neighborhood is some set of pixels, defined by their locations relative to that pixel. In order to implement the filtration technique, we have used the sobel filter. The sobel filter is basically an edge detection algorithm which creates an image emphasizing edges.

The sobel filter method returns a 3x3 filter h , that emphasizing horizontal edges by approximating a vertical gradient. We used the transpose of the sobel filter to emphasize vertical edges.

The operator uses two 3x3 kernels which are convolved with the original image to calculate approximations of the derivatives – one for horizontal changes, and one for vertical. If we define A as the source image, and G_x and G_y are two images which at each point contain the horizontal and vertical derivative approximations respectively.

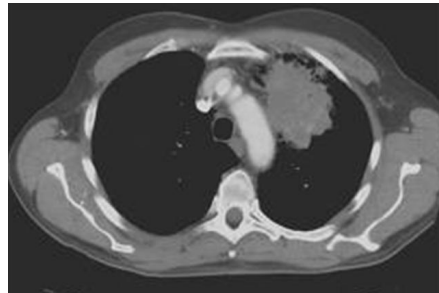


Fig. 3.4 (a) Original Image



Fig. 3.4 (b) Image after Filtration

IV. FEATURE EXTRACTION

Feature extraction is a type of dimensionality reduction that efficiently represents interesting parts of an image as a compact feature vector. This approach is useful when image sizes are large and a reduced feature representation is required to quickly complete tasks such as image matching and retrieval [9]. Feature extraction involves reducing the amount of resources required to describe a large set of data. When performing analysis of complex data one of the major problems stems from the number of variables involved. Analysis with a large number of variables generally requires a large amount of memory and computation power, also it may cause a classification algorithm to overfit to training samples and generalize poorly to new samples. Feature extraction is a general term for methods of constructing combinations of the variables to get around these problems while still describing the data with sufficient accuracy.

A statistical method of examining texture that considers the spatial relationship of pixels is the gray-level co-occurrence matrix (GLCM) [11], also known as the gray-level spatial dependence matrix. The GLCM functions characterize 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, creating a GLCM, and then extracting statistical measures from this matrix.

In this stage, we have used the GLCM – Gray Level Co-occurrence Matrix technique to detect and isolate desired shapes from the pre-processed image. The method `graycomatrix()` creates a gray level co-occurrence matrix from image I . Another name for this is a gray-level spatial dependence matrix. `Graycomatrix` creates the GLCM by calculating how often a pixel with gray-level (grayscale intensity) value i occurs horizontally adjacent to a pixel with the value j . The `graycoprops()` method accepts two parameters which are contrast, homogeneity and energy.



Fig. 4.1 Output Obtained from GLCM Method

V. CLASSIFICATION

Classification is the final step in the lung cancer detection system. The technique used for classification is artificial neural networks. Artificial Neural Networks are relatively crude electronic network of nervous based on the neural structure of the brain. They process records one at a time and learn by comparing their classification of the record with the known actual classification of the record. The errors from the first record is fed back into the network and used to modify the networks algorithm for further iterations.

The Artificial Neural Network classifies the presence of cancer by using three parameters which are obtained after performing feature extraction. These three parameters are entropy, contrast and energy. The neural network uses a regression based training model for detecting the presence of lung cancer nodules within the image.

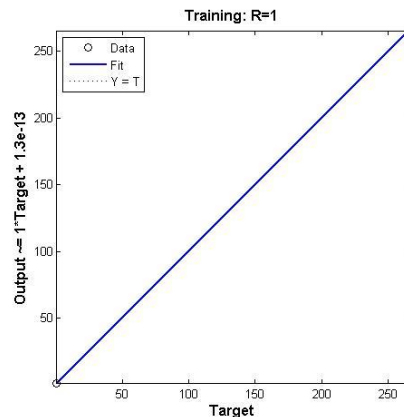


Fig. 5.1 Regression Training Graph

VI. CONCLUSION AND FUTURE SCOPE

Lung cancer is one of the most dangerous diseases in the world. Correct diagnosis and early detection of lung cancer can increase the overall survival rate. The present lung cancer detection techniques include X-ray, MRI, CT scan and PET images. The physicians diagnose the disease on the basis of these detection techniques. Based on this, various treatments are carried out on the patients. Such treatments include chemotherapy, radiation therapy and surgery. Hence, an attempt has been made to develop a system which is capable detecting the presence of lung cancer at an early stage by using various image pre-processing techniques and artificial neural networks. CT scan images are acquired from cancer imaging archive and kaggle. The pre-processing techniques include histogram equalization, segmentation by thresholding and image filtration. From the extracted region of interest, three features are extracted i.e. entropy, contrast and energy. These three features help to identify the presence of lung cancer. The results indicate that the tumors are of different dimensions. The results show good potential for lung cancer detection at an early stage.

Also, for classification purpose, Artificial Neural Networks have been used. The network is an attractive approach of data modeling and is capable of learning from the input data. The neural network is based on the regression training model.

For future work, we can implement this technique on some more images. Increasing the number of images for training can further improve the accuracy of the system. Also, a similar system can be developed for X-ray and MRIs. Classification can be improved by using supervised learning techniques like SVM (support vector machine).

VII. REFERENCES

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