

Lung Cancer Detection by using Adam Algorithm and Convolutional Neural Network

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Abstract- Lung cancer, also known as lung carcinoma is one of the main reasons of casualty among people all over the world. The chance of survival rates among people can increase if lung cancer is detected at an early stage. As per current survival rate, only 14% patients can survive for 5 years. It can be increased by 35% and make survival rate nearly 50% if the disease is detected in her early stage. This is only possible with effective screening test to detect the lung cancer. Many techniques such as filtering, image thresholding, histogram equalization based on image pre-processing and Gray Level Co-occurrence Matrix (GLCM) techniques based on feature extraction are used for detection of the this disease. But to reduce the mortality from lung cancer a fast, accurate and effective screening test is required for early stage detection of the target disease. The proposed approach using Adam algorithm and Convolutional neural network on CT scan images is among best solution.

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

I. INTRODUCTION

Lung Cancer is assumed the main reason of mortality among all type of cancers throughout the world and it is difficult to notice the presence of cancerous cells in lungs at an early stage because the symptoms only appear at later stages and thus increasing the rate of loss of lives [1-3]. According to the American Cancer Society, the current 5-year death rate is around 72% which is significantly high in comparison to other cancers including breast, colon and prostate. Death from lung cancer is straightforwardly reliant upon the cancer growth and its detection time. The timely recognition of lung cancer can decrease the death rate from 51% to 76% [3].

Different techniques for example Sputum Cytology, Computed Tomography (CT Scans), Magnetic Resonance Imaging (MRI), and Chest Radiograph (X-Ray) are used to find out the presence of the lung cancer [4]. But these methods are more time consuming and expensive. Further, most of the techniques can find lung cancer at a later stage when the symptoms start to appear, thus increasing the mortality rate among patients. Therefore, there is a urgent requirement of a system to sense the presence of lung cancer at near the beginning stage in order to decrease the death rate among patients from lung cancer [5]. Image processing techniques act as a fine class means to enhance the physical investigation of CT scans [4-6].

To overcome these limitations, we propose a machine-based auto lung cancer recognition system to detect the presence of lung cancer in its premature stages based on the examination of CT scans of the lungs [4,6,7]. To obtain desired results, we have designed a preprocessing stage comprising of histogram equalization, segmentation by thresholding and image filtrations [8-10]. Image representation can be more simplified or modified using image segmentation to make it easier for analysis and more meaningful representation. Different partition of digital image is processed using image segmentation. Global contrast of colors of image is increased by using its histogram and applying histogram equalization. We segmented the image into different segments using thresholding method because of its simplicity and easiness. Thresholding can be used to make binary images from grayscale images. The thresholding function is proposed by Nobuyuki Otsu [11]. It converts grayscale image into binary image and performs automatic clustering based upon image thresholding. Lot of applications such as edge detection, noise removal, image sharpening and smoothing are used by image filtering. A filter is used to changes color or shades of the image by applying some function to each or some pixels of the image. A sobel filter has been used to perform the process of filtration.

We extracted features by applying gray level co-occurrence matrix (GLCM) techniques. 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. We classified the image using Convolutional neural network (CNN) for the image classification.

II. METHODOLOGY

The project is divided into three main processes: Image Pre-processing, feature extraction and classification. Further pre-processing has been divided into histogram equalization, segmentation by thresholding and image filtration. We

have used MATLAB for implementing this project. Figure (2.1) depicts a detailed flow of process followed in the lung cancer detection system.

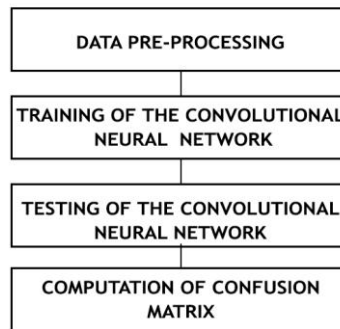


Fig. 2.1. Lung Cancer Detection System

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

2.1 Image Acquisition

We got images of CT scan of the lung cancer patients from Cancer Imaging Archive and Kaggle for our proposed research work in the format of Digital Imaging and Communications in Medicine (DICOM). MRI and X-rays are having more amounts of noise and high variations but on the other side CT scan images are having less amount of noise and low fluctuations. Less distortion and better clarity as compared to others is the main advantage of using CT scans in this project.

The images are having a 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.

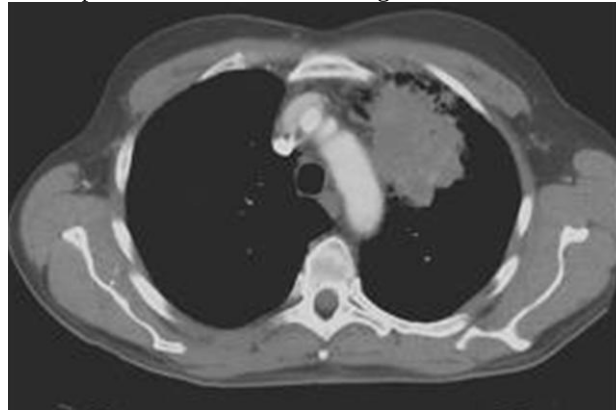


Fig. 2.2. Input CT Scan Image

III. IMAGE PRE-PROCESSING

Pre-processing is common when it comes to operations with images. Image pre-processing involves a set of operations or functions in order to enhance the contrast, illumination, intensity, removal of noise and edge detection. Several of the frequently 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.

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 distribution out the most regular intensity values. This process is useful when the foreground

and background of the image are together 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 execute histogram equalization and the function, `imhist()` is used to display the histogram of the image.

Let I is a image of size $M \times N$ such that $I = \{I(x, y) : 1 \leq x \leq M, 1 \leq y \leq N\}$ and $0 \leq I(x, y) \leq 255$. $I(x, y)$ represents the pixel value of the image and it ranges from 0 to 255 for grayscale images. Let p denote the normalized histogram of I with a scale for each possible intensity.

P = number of pixels with intensity n divide by total number of pixels

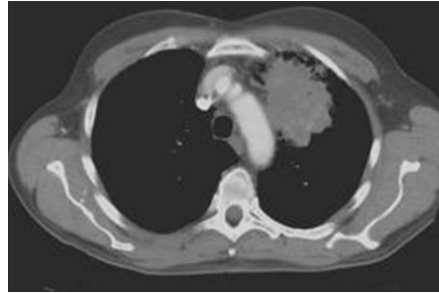


Fig. 3.1 (a) Original Image



Fig. 3.1 (b) Histogram Equalization Image

The intensity values of pixels of the image are divided into non overlapping continuous intervals and called as bins. All bins are of equal size and are adjacent to each other. Rectangles are constructed over bins with height proportional to bin frequency that is the number of pixels in that bin. Normalized the histogram to show the relative frequencies. The graph shows the ratio of pixels along the x-axis. The histogram equalized image g will be defined by using the following formula with floor function to round down the value to the nearest integer:

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

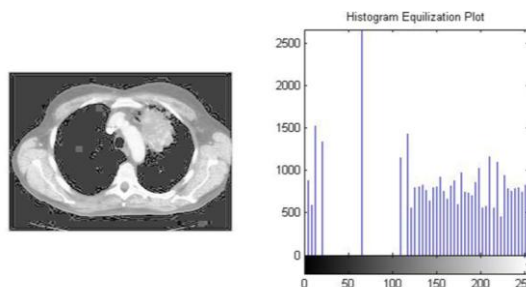


Fig. 3.2. Histogram of the Image

3.2 Segmentation

The method of partitioning an image into numerous segments is identified as Image Segmentation. The main aim of partitioning image is to analysis easier and more expressively understanding of the image by doing modification or changing the representation of the image. Segmentation is the process of dividing image into separate blocks. Combination of all these blocks makes the whole image or some set of blocks makes a part of image.

For the purpose of segmentation, we have used the thresholding technique. Segmentation is one of the simplest and most widely used methods of thresholding. Binary images can be obtained from a grayscale image by using the thresholding technique. We have used the function `graythresh()` is used to perform image thresholding. The `graythresh()` function based on Otsu's method calculates a global threshold level. The threshold level is used to change an intensity image to a binary image. Otsu's method chooses the threshold to minimize the interclass variable of the black and white pixels.

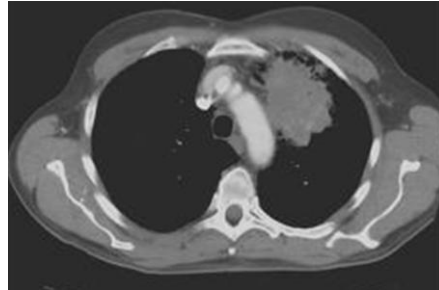


Fig. 3.3 (a) Original Image



Fig. 3.3 (b) Segmented Image

Otsu's method is used to accomplish image thresholding based on grouping or to convert a grayscale image into a binary image [11]. Assumption of this algorithm is that the image consist of two category of pixels follows bimodal histogram. The algorithm minimizes the variance of the two class and estimate the optimum threshold to divide the two category of the pixel class. We thoroughly explore for the threshold and diminishes the intra-class variance demarcated 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

Different applications such as edge detection, noise removal, sharpening and smoothing are use image filtration. Within a image, a small array is applied to every pixel with its neighbors by the kernel is known as image filter. A pixel is defined with their set of other pixels in the neighborhood and the locations of the neighborhood pixel relative to pixel in scene. During filtering, output value of the image pixel is estimated by applying some formula to the pixel with their neighbor pixels. 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.

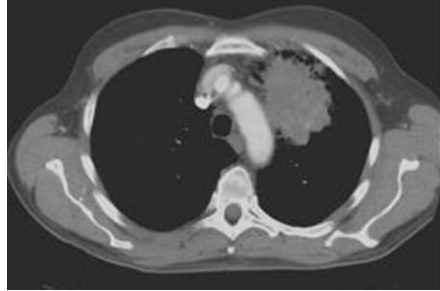


Fig. 3.4 (a) Original Image



Fig. 3.4 (b) Image after Filtration

IV. ADAM ALGORITHM

In classical stochastic gradient descent, single learning rate α of network remains same for all weights and it does not change during training of the neural network. But in case of Adam, different learning rate is used for different weight parameters and independently updated as per their learning experience [12]. Adam is used as an optimization algorithm. It updates their network weights repeatedly as training of the network proceeds as per training data, opposite to stochastic gradient descent in which no change during training of the network. First and second level of the gradients are used to calculate the separate adaptive learning rate for different parameters. Adam is a combined extension of two stochastic gradient descent algorithms namely Adaptive Gradient Algorithm (AdaGrad) and Root Mean Square Propagation (RMSProp). AdaGrad keeps learning rate for each parameter which update their performance on problems with sparse gradients. RMSProp also keeps rate for each parameter which update them as per the mean of current amount of the gradients for the parameter. Adam update learning rate of the parameter using mean of the second moments along with average of gradient. Two parameters are used to control the decay rates of the changing means. Exponential moving average of the gradient and the squared gradient are calculated by the algorithm. The initial recommended value of decay rate controls is taken nearly 1.0 and it tends towards zero. Some benefits of Adam are easy to implement, efficient, less memory requirements, no effect of diagonal rescale of the gradients, well suited for large data problems, good for very noisy/or sparse gradients etc.

V. CONVOLUTIONAL NEURAL NETWORK

Classification is the final step in the lung cancer detection system. The technique used for classification is Convolutional neural networks. Convolutional Neural Networks are multilayered networks of neurons based on the general neural structure of the brain. The process records one at a time and learn by comparing their classification of the record with the known actual classification of the record. It is back propagation network in which the errors which are obtained from the first record is fed back into the network and used to modify the networks algorithm for further iterations.

The Convolutional 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.

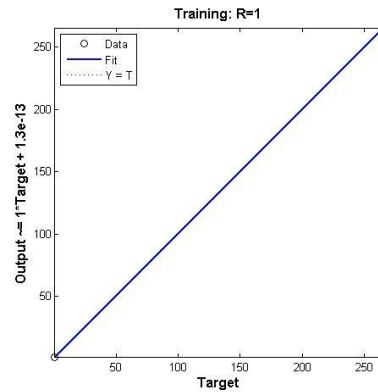


Fig. 5.1 Regression Training Graph

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 Convolutional 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. Further, for the purpose of classification, Convolutional Neural Networks have been used. The network is an attractive approach of data modelling 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 medical databases where the patient ID can be used to monitor the CT scan 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) or using a Convolutional neural network.

VII. REFERENCES

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