

An Early Prediction of Lung Cancer using CT Scan Images

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Abstract - Lung cancer is a common occurrence type in a population and one among lethal cancers. Recently, out of several research presented by diverse health agencies; it is obvious that the fatality ratio is rising due to delayed diagnosis of lung cancer. Hence, an artificial intelligence-based diagnosis is required to find out the onset of lung nodule micro-calcification, which may support the doctors and radiologists to accurately predict it through image processing methods. In this paper, a novel technique is proposed to identify the nodule micro-calcification pattern by using its physical features. The physical features that considered are the reflection coefficients and mass densities of the binned CT image of lung. The physical features measurements reiterate once again the existence of malignant nodule. Then, by applying the methods of thresholding and in interpolation of physical features, a three-dimensional (3D) projected image of the region of interest (ROI) is achieved in respect of physical dimensions. Thus, the nodule size is calculated from 3D projection. This concept is used to verify how best in classification with 100 malignant images (the nodule presence) and 10 normal images (the nodule absence). Apart size measurement, the proposed method supports SVM classifier to act for excellent classification from normal and malignant input images by just using two physical features. The classifier exhibited an accuracy of 98%.

Keywords – Lung cancer, CT image, micro-calcification, reflection coefficient, mass density, tissue impedance

I. INTRODUCTION

In general, the pulmonary nodules and micro-calcifications are regularly categorized based on spherical opaque bodies with boundaries of parenchymal lacerations, quantifying with diameter of less 3cm [1]. Though, not every pulmonary nodule and micro-calcifications are harmful (depicted in fig 1). Several tiny lumped opacities may misrepresent the nodules, specifically when on examined in a one-dimensional plane, however they are featured excellent on multiple plane images like two-dimension uniform opaque lumps, lesions, plate like atelectasis or respiratory tract anomalies. In medical care, Computer Tomography (CT) takes onto be highly responsive and renowned imaging procedure for detecting and diagnosing the nodule with relative merits on spatial resolution, expense, prevalence, and noninvasiveness [2]. CT is the quite efficient technique to detect the pulmonary nodule and micro-calcifications because of its potential to create 3-dimension images of chest cavity, producing images of nodules, micro-calcifications and pathological tumor at high resolution. An image of CT scan through computer processes in order to support diagnosis of pulmonary nodule has been extensively employed in hospitals. The radiologists require to study various characteristics namely size, location, texture and shape etc. of the nodules and micro-calcifications from CT scan images to accomplish diagnosing job. Still, this is quite formidable and laborious, because of several constraints, namely misconception, exhaustive including restricted experience professionally.

Presently, the powerful method in order to detect and evaluate the condition of pulmonary nodule and micro-calcification would be biopsy technique, however this technique is largely invasive method that involved extraction of tissue sampled directly from the nodules and micro-calcifications. With just removing a smaller nodule and micro-calcification part cannot represent complete characteristics of the nodule precisely because of its heterogeneous features. Hence, sophisticated computer-assisted diagnosis based systems will be required to support radiologists to coping these problems, by interpreting the data of diagnosis to take some medical actions. The main

anomalies associated to lung are nodules and calcifications from practitioner's viewpoint. Nodules are unsuspicious in comparison with calcifications. There are two types of calcifications, one as macro and other as micro-calcification. Macro-calcifications [3] considered to be huge calcium deposition in the lung tissue, developed due to many factors. But, smaller calcium deposition termed micro-calcifications, in the lung tissue cause the highly susceptible to develop cancer.

II. EXTRACTION METHODS OF IMAGE DETAILS

Apart the presence of several nodules and micro-calcifications, particular nodule and micro-calcification features that determine ability of detection contain their sizes, shapes, densities, marginalization, sites and association to vessel or pleural systems [4]. Connection with the surfaces of vascular or pleural structures heightens the chances of non-detection and misapprehension of pleural swelling or damages. Tiny inadequately determined low density nodules and micro-calcification in main sites are increasingly complicated to detect on comparing with superficial bigger nodules and micro-calcifications well marginalized scars. The sensitivity of detection of perihilar nodules and micro-calcifications was reduced to half in comparison with detection of peripheral nodules [5]. This perihilar nodule and micro-calcification imperceptibility enhanced the sensitivity in little value.

The recognition and classification of small blobs of lung nodules and micro-calcifications from radiological images of thoracic cavity are frequent challenges [6]. The decrease in fatality due to lung cancer that proved for wider acceptance of examination of lung cancer has stressed the need for identification and assessment of nodule [7]. Precise detection of substantial nodules and micro-calcifications is a precondition that are enhanced on training which used as a technique for computer-assisted detection. Subsequently, the features of detected nodules and micro-calcifications exhibit an intrinsic difference. Nodules and micro-calcifications that detected are assessed through evaluation by radiology primarily founded on their shapes and sizes.

Pattern Recognition

Several image processing methods are beneficial to detect micro-calcification and classify the cancer into benign and malignancy with the features of texture and shape. An extensive publication review demonstrates that traditional method in detection and classification of micro-calcification includes enhancement [8], accompanied by segmentation [9], next extraction of features [10], and finally the classification [11]. The images of CT [12] and magnetic resonance imaging (MRI) are employed in detection of lung cancer. Initially, the X-ray images are regarded as a main examining method to identify any lung anomalies, specifically lung cancer. X-ray is also a type of non-intrusive method with the benefits of being less expensive, time saving, and greater accuracy. The growth of pattern recognition in image processing requires to be presented in a convenient style to support the practitioner for instantly suggesting the crucial needed counsel to the patients concerning area of concern. This paper suggests a uniting the pattern recognition associated to micro-calcification and modern image processing method to provide a convenient procedure to a medical practitioner. The suggested technique applies a novel method to estimate the micro-calcification area size by calculating the physical features of the recognized micro-calcification in images. In order to extract the lesion physical features in the images, firstly, the binning of input images will be performed. The method of binning splits an image into several sub-images, and this is specifically beneficial to reach near to the damaged region and moreover carry out assessment just on the chosen sub image. The idea of binning is greatly beneficial to study marine images, and here in this paper, this idea is fetched and applied to investigate medical images to assess micro-calcification area size. Further, the reflection coefficient and mass density computations from lung CT or MRI images use image processing method which is completely uncommon technique and adopted as a research tool here.

It is particularly considered here the lung CT image to identify the presence of micro-calcification. A tiny calcium deposition that spread in some manner which become cancer is termed as micro-calcification. Such calcification is divided into benign and malignant based on its shape, size, boundaries, and spread, and the existence of calcium compound. As an example, the benign cancer is typically due to calcium oxalate, whereas malignancy is due to calcium phosphate. From literature survey, it is found that micro-calcification is one of the main factor that may lead to some cancerous issues. Its identification in beginning and convenient depiction to medicos shall be greatly beneficial for examining its shape, size, and distribution of the calcium oxalate or calcium phosphate. The micro-calcification seems to be luminous white specks. The intensity of micro-calcification is outweighing the intensity of other zones in the lung image. It is necessary to detect the micro-calcification as region of interest (ROI). This is attained by applying image processing methods to identify the laceration from other tissues. Recognizing the pattern of the laceration is essential for deeper investigation and classification of anomalies that occur in lungs.

The method of recognizing pattern is more helpful in classification of the image features on the basis of commonalities present in some appearances [13]. For identifying the pattern associated to laceration, its related features are to be obtained. Usually, several segmentation methods are applied to detect the ROI.

III. BACKGROUND AND APPROACH

The suggested technique is helpful to identify the micro-calcification pattern in the image, which varies from existing traditional methods of pattern recognition. Here, the micro-calcification pattern is determined from its physical features. The physical features that considered are the mass densities and reflection coefficients of nodule region in CT or MRI images. The identified pattern of micro-calcification is represented in 3D image form to determine the shape and the size of micro-calcification. The suggested technique comprises 9 stages and they are discussed elaborately below.

Method to measure reflection coefficient

In lung tissues, a nodule cancerous growth (micro-calcification) is developed due to calcium depositions. If infected lung with such anomaly put under scan, the lacerated bodies reflect more energy. Accordingly, it is possible to calculate the reflection coefficient for the whole image including the lesion part. In the lesion part, the reflected energy and reflection coefficient are both high. An image could be modeled as a two-dimensional function $f(x,y)$ with two components as

$$f(x,y) = r(x,y)i(x,y) \quad (1)$$

Where $i(x,y)$ is the illumination component and $r(x,y)$ is the reflectance component.

$0 < i(x,y) < \infty, 0 < r(x,y) < 1, r = 0$ represents total absorption, and $r = 1$ represents total reflectance.

Estimating reflection coefficient using curve fitting of least square method

Once choosing the suitable bin that contains nodule from second level of binning, in order to detect ROI, it is compulsory to evaluate the reflection coefficients for setting the threshold. The reflection coefficients for every row is graphed then by regarding the respective column values of bin on x axis and the spread of the reflection coefficients on y axis.

$$\sum_i \left(\frac{y - y_i}{\sigma_i} \right)^2 \quad (1.2)$$

Where y is best fitted value, y_i is measured data and σ_i is the standard deviation estimate of y_i

Mass density measurement

The mass density is fundamentally a relation by mass per volume. Since the nodule region (micro-calcification) is a calcium deposition, the mass density of it can be determined. Micro-calcification arises due to the calcium deposition namely calcium phosphate and calcium oxalate. The mass of ROI is determined from relevant images of second-level bin by measuring its respective volume. With the measured values, ROI mass density is evaluated. The evaluated mass density value is depicted.

Reflection coefficient and mass density mapping

The mass densities of complete 12 binned images of second level bins are determined and described and the malignant micro-calcified ROI mass density range lies between 2.7 and 3.1 g/cm³. The reflection coefficient range that takes the value from 0.9 to 1 is mapped to the mass density that takes the values from 2.7 to 3.1 and this performance is depicted in Fig. 1. Since both the reflection coefficients and mass densities are determined on the basis of pixel intensities in ROI, the correlation between them happens on linear scale.

Determination of micro-calcification size

Since the 3D projection of the binned image can be performed in terms of the distance, the ROI size is conveniently evaluated. In Fig, the x and y axes are depicted as the width and height of the binned image and it constitutes a cluster of the micro-calcification.

The method of Interpolation estimates the data at unknown points from known neighbor data points. It is hard to locate exact position of micro-calcification in CT images by visual. The image just provides the information on intensities on the basis of the nature of lung tissue. The obtained CT image when on gray scale conversion, the intensities likely to differ between 0 and 255. Using these data and the values of reflection coefficient and mass density, the size of malignant micro-calcification is calculated possibly from the pattern in 3D projection.

Calculating tissue impedance

The tissue impedances are calculated from reflection coefficients using equation (3). The Fig 1 and 2 depicts the plot of tissue.

$$\Gamma = \frac{Z_L - Z_0}{Z_L + Z_0} \quad (3)$$

In which Γ is reflection coefficient, Z_0 is air impedance which is 376Ω and Z_L is the tissue impedance.

IV. EXPERIMENT RESULTS AND INFERENCES

The results that follows are discussed in simplified manner. Fig 1 is an input image. The first level binned images of 12 in number are depicted in Fig 2. The 7th binned image comprises micro-calcified ROI. Hence, this sixth image is considered for second level binning and the results of second level binning is depicted in Fig. 2 and bin [2, 2] comprised the micro-calcification nodule.

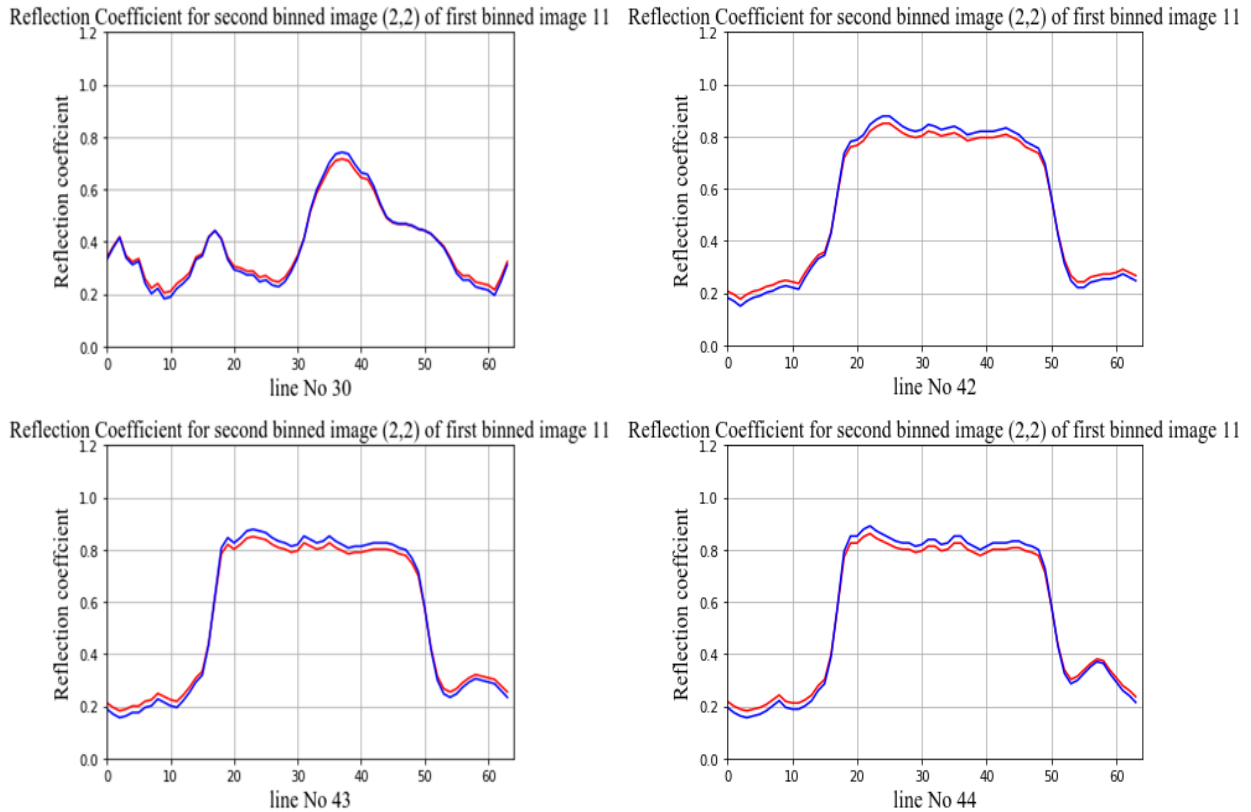


Fig. 1 Reflection coefficient plot for bin [2, 2] with row nos. 30 and 42–44

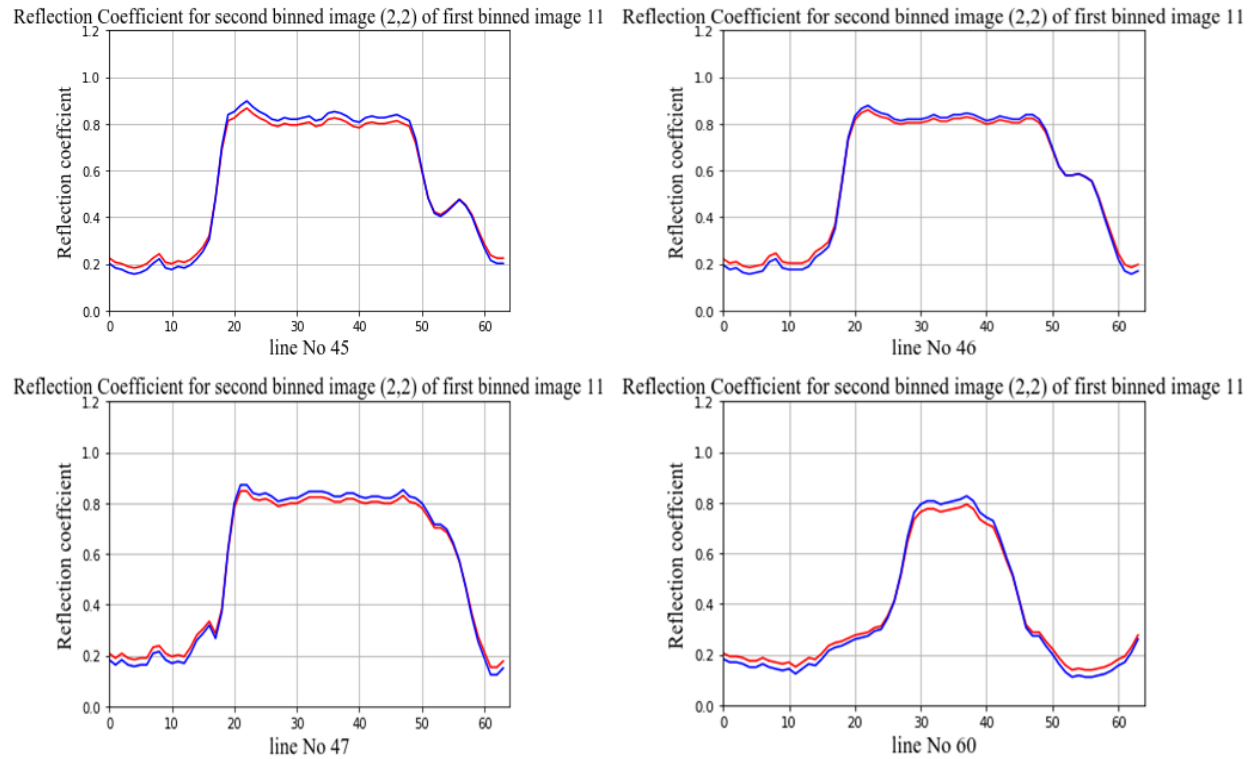


Fig. 2 Reflection coefficient plot for bin [2, 2] with row nos. 45-47 and 60

V. CONCLUSION

This investigation suggested a new automation method with CAD operation namely binning computation of the reflection coefficients and mass densities to derive a 3D projection of nodule pattern from lung CT images. In segmenting the nodule successfully, thresholding on the basis of the reflection coefficient was performed. Additionally, using mass density values, the type of calcium deposit in the lung can be determined. The computation of nodule size was carried out using interpolation over image intensity and the reflection coefficient. Therefrom, the nodule was precisely identified using 3D projection of it, and thereby its size was accurately detected. The recognition method applied for investigation aimed majorly by using physical features namely reflection coefficient and mass density. Hence this method is unique, and has been unapplied or unstudied comprehensively in any of earlier researches. The prediction between normal and malignancy during classification achieved the accuracy with 98%. Therefore, the suggested method is demonstrated as an efficient technique for diagnoses and classification of the lung cancer. The 3D projection of nodule is a convenient graphical representation, which is so easy to comprehend the nodule size and shape by doctors, radiologists and patients.

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