Analysis of Lung Nodules using texture analysis in Medical Images

Anisha M. Lal[1] D.Aju[2]

[1,2]School of Computing Science and Engineering, VIT University, Vellore, India.

Abstract— Texture is an important property of the image. Texture analysis techniques play a vital role in medical imaging to automatically extract parameters that are used to classify the normal and abnormal tissues. Lung cancer is a terminal disease that primarily affects the lungs. However, lung cancer can spread to other tissues and organs through the lymph nodes or the blood stream if not detected early and treated. There are several diagnostic methods of imaging technology that are used by radiologists in the detection of lung cancer, and most lung cancer is detected by routine chest X-rays for other issues before any signs or symptoms of lung cancer arise. Image analysis based on texture feature of an image is still a complex and challenging problem, and hence texture feature based technique is the approach which has been selected for analysis of medical images. Here an analysis is done on lung nodules using texture analysis in various medical images. Mostly this paper concentrates on Chest X-rays images and CT scan images of lung.

Key words: texture analysis, lung cancer, Chest X-ray, CT scan

I. INTRODUCTION

Lung cancer is the most common cause of cancer-related death in the western world, with approximately 3 million new cases per year estimated worldwide. Lung cancer has no symptoms in its early stages. According to the American Cancer Society, More people die of lung cancer than of colon, breast, cervix and prostate cancers combined. Imaging techniques play an essential role in the diagnosis, staging, and follow-up of patients with lung cancer.

Lung cancer is a terminal disease that primarily affects the lungs of the human beings. However, lung cancer can spread to other tissues and organs through the lymph nodes or the blood stream if not detected early and treated. There are several diagnostic methods of imaging technology that are used by radiologists in the detection of lung cancer, and most lung cancer is detected by routine chest X-rays for other issues before any signs or symptoms of lung cancer arise. Prognosis and cure of lung cancer depend highly on early detection of SCLC and NSCLC. Survival rate of a patient (5 yr old cancer) is approximately 40% when lung cancer is detected in early stage. Lung cancers (87%) are thought to result from smoking or passive smoking. Physical characteristics of nodules (rate of growth, pattern of calcification, type of margins) are very important in investigation of solitary lung nodules. Malignant nodule’s have a fast doubling time (25-450 days), whereas benign nodules are stable (doubling time, >500 days). With the increasing of the mortality rate for lung cancer, x-ray computed tomography has been used for detection of lung cancer at early stages [3]. Computer- aided diagnosis (CAD) is a very effective approach for improving diagnostic accuracy. A CAD system is not to entrust the diagnosis to a machine, but rather that a machine algorithm acts as a support to the radiologist and points out locations of suspicious objects, so that the overall sensitivity (detection rate) is raised. CAD systems meet four main objectives, which are: improving the quality and accuracy of diagnosis, increasing therapy success by early detection of cancer, avoiding unnecessary biopsies and reducing radiologist interpretation time [3].

Here, texture parameters to classify lungs nodules (benign or malignant) are analyzed and proposed. Texture is an important property of the image. Texture analysis techniques played a vital role in medical imaging to automatically extract parameters that are used to classify normal and abnormal tissues.

II. LITERATURE SURVEY

According to the studies carried out, for variety of reasons, small tangential lung nodules are often tricky to spot out on chest radiographs. Survey done on some papers are given below,

M. S. Ahmad, M. Shahid Naweed, M. Nisa “Application of texture analysis in the assessment of chest radiographs” *International Journal of Video & Image Processing and Network Security IJVIPNS* Vol: 9 No: 9 [1].

- An automated imaging system for the classification between normal and abnormal tissues in medical images obtained by chest radiography scans has been proposed.
- Results show that performance of radiologists in the determination and investigation between malignant and non-malignant lung images can be enhanced by using texture analysis techniques.
- Results show that texture analysis techniques are powerful to recognize abnormalities from medical images.

Neeraj Sharma, Amit K. Ray, Shiru Sharma, K. K. Shukla, Satyajit Pradhan, and Lalit M. Aggarwal “Segmentation and classification of medical images using texture-primitive features: Application of BAM-type artificial neural network “*Journal of Medical Physics J Med Phys*. 2008 Jul–Sep; 33(3): 119–126 [2].

- An algorithm has been designed and developed for analysis of medical images based on hybridization of syntactic and statistical approaches, using artificial neural network (ANN).
- Algorithm can be modified with other statistical features.

S A Patil and V R Udipi “Chest X-ray features extraction for lung cancer classification” *Journal of Scientific & Industrial Research* Vol.69, April 2010, pp. 271-277[3].

- This study presents a computer algorithm which consists of four main steps, image acquisition, image pre-processing, nodule candidate detection an feature extraction for nodule detection in chest radiographs.

K. Murphy, B. van Ginneken, A.M.R. Schilham, B.J. de Hoop, H.A. Gietema, M. Prokop “A large-scale evaluation of automatic pulmonary nodule detection in chest CT using local image features and k-nearest-neighbour classification" *Medical Image Analysis* 13 (2009) 757–770, 2009 Elsevier[4].

- CAD system for the automatic detection of pulmonary nodules has been presented and extensively evaluated, particularly in the context of lung cancer screening data.
- Accurate lung segmentation was not done so some false results were obtained.

Yang Yu, Hong Zhao "A Texture-based Morphologic Enhancement Filter in Two- dimensional Thoracic CT scans"*2006 IEEE*, Pages 850-855 [5].

- A new enhancement filter in two-dimensional space were introduced
- Based on nodular texture feature and mathematical morphology the enhancement filter is used to automatically extract and enhance the contrast of the region of interests (ROI) in thoracic computer tomography (CT) images.
- Classification has to be performed.

Bram van Ginneken, Shigehiko Katsuragawa, Bart M. ter Haar Romeny, Kunio Doi, and Max A. Viergever "Automatic Detection of Abnormalities in Chest Radiographs Using Local Texture Analysis" *IEEE Transactions on Medical Imaging*, Vol. 21, No. 2, February 2002 [6].

- A fully automatic method is done to detect abnormalities in chest radiographs.
- The method is based on texture analysis on local regions in the image which are segmented automatically.

Omar S. Al-Kadi, and D. Watson "Texture Analysis of Aggressive and Nonaggressive Lung Tumor CE CT Images" *IEEE Transactions on Biomedical Engineering*, Vol. 55, No. 7, July 2008 [7].

- Image acquisition is done and features are extracted using fractal dimension to differentiate aggressive and non-aggressive lung tumor.
- The techniques were applied in CT images can be tested with different image modalities.

Binsheng Zhao, Gordon Gamsu, Michelle S. Ginsberg, Li Jiang, and Lawrence H. Schwartz "Automatic detection of small lung nodules on CT utilizing a local density maximum algorithm" *Journal of Applied Clinical Medical Physics*, Vol. 4, No. 3, Summer 2003 [8].

- A three-step approach, consisting of automatic extraction of the lungs, detection of higher density structures in the extracted lungs, and elimination of false-positive results among the detected nodule candidates were adopted.
- The method has been validated with small lung nodules of 2mm size.

Study	**Method**	**2D/3D**	**Modality**	**Performance**
M. S. Ahmad et al.	Texture analysis techniques were used to recognize normal and abnormal tissues. Classification is done using artificial neural networks.	2D	Chest radiographs	92% accuracy has been classified
Neeraj Sharma et al.	An algorithm has been designed and developed for analysis of medical images based on hybridization of syntactic and statistical approaches, using artificial neural network (ANN).	2D	CT image	Segmentation has been performed well compared to other conventional methods
S A Patil and V R Udipi	A computer algorithm which consists of four main steps, image acquisition, image pre-processing, nodule candidate detection an feature extraction for nodule detection	2D	Chest radiographs	Feature extraction part has been concentrated more and performed well.
K. Murphy et al.	CAD system for the automatic detection of pulmonary nodules has been presented and extensively evaluated	2D	Chest CT	The results are clearly substantially better for completely calcified nodules, particularly as the rate of FPs increases
Yang Yu,	Based on nodular	2D	Thoracic	Mainly concentrate

Hong Zhao	texture feature and mathematical morphology the enhancement filter is used to automatically extract and enhance the contrast of the region of interests (ROI) in thoracic computer tomography (CT) images		CT image	d on enhancing the quality of the acquired image and extracting the ROI
Bram van Ginneken et al.	The method is based on texture analysis on local regions in the image which are segmented automatically	2D	Chest radiographs	The results were fairly accurate
Omar S. Al-Kadi, and D. Watson	Image acquisition is done and features are extracted using fractal dimension to differentiate aggressive and non-aggressive lung tumor.	2D	CE CT image	Prediction can be improved
Binsheng Zhao et al.	Detection of nodule candidates using local density maximum algorithm.	2D	CT image	Concentrated on reduction of false positive results.

Table 1 : Study on the methods used and the performance obtained

Study	Segmentation method	Modality	Performance
Neeraj Sharma et al.	Segmentation based on textural feature methods has been performed.	CT image	Segmentation has been performed well compared to other conventional methods
S A Patil and V R Udipi	Lung field segmentation by pixel classification Region based segmentation techniques were applied	Chest radiographs	Cancerous portion in lung images are separated after segmentation
K. Murphy et al.	Segmentation by registration scheme was done which was proposed by Slumier et al.	Chest CT	Segmentation results were better for further classification
Yang Yu, Hong Zhao	Segmentation of lung CT images based on nodular texture features has been performed	CT image	Segmentation results are better, even the missing nodules are considered

Table 2 :Study on segmentation techniques performed

III. PREPROCESSING

The image filtering or preprocessing depends mainly on the quality of the image acquired from image acquisition system. The main aim of image preprocessing is to suppress unwanted noise and to enhance image features important from further analysis point of view, and is most of the time specific in nature depending upon the type of noise present in the image. (For example, in case of image with poor ‘brightness and contrast,’ histogram equalization can be used to improve the brightness and contrast of an image.) In analysis of medical images, Neeraj Sharma et al. tried to avoid image preprocessing unless and until it is very much necessary as image preprocessing typically decreases image information content.[2]

S A Patil and V R Udipi obtained images using image acquisition method and then applied pre-processing algorithms, including size normalization and image filtering. Features useful for diagnosis and analysis, require separation of lung fields from background.[3]

K. Murphy et al. adopted some sub-sampling of image data for preprocessing. Before beginning with nodule detection some initial processing is carried out on the original image data as described below. Sub-sampling of image data is done. The first step is to down-sample the data to improve the speed of the algorithm. Use of the full-size images was extremely computationally expensive and gave little or no improvement to the results. The down-sampling is by means of block-averaging such that the matrix size of 512 _ 512 in the original Nelson Trial images is reduced to 256 _ 256, with the number of slices reduced to form isotropically sampled data. Linear interpolation is used to determine grey-values between voxel locations. The number of slices in the down-sampled scans varied between 149 and 428 with an average of 223 slices per scan.[4]

IV. SEGMENTATION

Segmentation is an important step in image analysis. Segmentation is a process of dividing an image into regions having similar properties, such as gray level, color, texture, brightness, contrast, etc. The techniques available for segmentation of images can be broadly classified into two classes: I) based on gray level — a) amplitude segmentation methods based on histogram features, b) edge-based segmentation, c) region-based segmentation; and II) based on textural feature.[2]

For some typical applications, particularly in the medical image processing, segmentation based on gray level does not give the desired results; in such applications, segmentation based on textural feature methods gives more reliable results; therefore, texture-based analysis is extensively used in analysis of medical images.[9-12] Image analysis based on texture feature of an image is still a complex and challenging problem, and hence texture feature based technique is the approach we have selected for analysis of medical images. Texture can be defined as something consisting of mutually related elements. Further, texture can be defined as spatial arrangement of texture primitives or texture element, sometimes also called textone, arranged in more or less periodic manner, where texture primitive is a group of pixels representing the simplest or basic subpattern. A texture may be fine, coarse, smooth, or grained, depending upon its tone and structure, where tone is based on pixel intensity properties in primitive while structure is the spatial relationship between primitives.

S A Patil and V R Udipi adopted Thresholding along with region based segmentation techniques were used to segment lung nodules in NSCLC images and cancerous portion in SCLC images from separated lung field area.[3]

K. Murphy et al. used a second pre-processing step which involves the segmentation of the lung volume from the surrounding tissues in the sub-sampled image. The mask obtained from this segmentation is used to ensure that nodule detection is performed within the lung volume only. This process has the two-fold advantage of reducing computation time and preventing the possible detection of false positive structures in regions of the image outside the lungs. Lung segmentation was carried out using an algorithm by Sluimer et al. (2005) based on that of Hu et al. (2001).[4

The studies carried out by different authors are given in the table II.

V. FEATURE EXTRACTION

This problem has been broadly dealt under the subject area of 'Pattern Recognition.' The main aim of pattern recognition is the classification of patterns and subpatterns in an image or scene. A pattern recognition system includes the following subsystems: subsystem to define pattern/texture class, subsystem to extract selected features, and subsystem for classification known as classifier. The pattern classes are normally defined in supervised mode; after this, the desired features are extracted by feature-extracting subsystem, and finally classification is done on the basis of extracted features by classifier. The three main approaches of pattern recognition for feature extraction and classification based on the type of features are as follows: 1) statistical approach, 2) syntactic or structural approach, and 3) spectral approach. In case of statistical approach, pattern/texture is defined by a set of statistically extracted features represented as vector in multidimensional feature space. The statistical features could be based on first-order, second-order, or higher-order statistics of gray level of an image. In case of syntactic approach, texture is defined by texture primitives, which are spatially organized according to placement rules to generate complete pattern. In case of spectral method, textures are defined by spatial frequencies and are evaluated by autocorrelation function of a texture. A brief survey of methods available for textural feature extraction and classification based on the above approaches is as follows: co-occurrence matrix method based on statistical description of gray level of an image, gray level run length method, fractal texture description method, syntactic method, Fourier filter method. As a comparison between the above-mentioned three approaches, spectral frequency–based methods are less efficient, while statistical methods are particularly useful for random patterns/textures; while for complex patterns, syntactic or structural methods give better results.[2]

Geometric and contrast features were estimated. First order statistical features were used to calculate the features.[3]

VI. CLASSIFICATION

Segmentation and classification can be achieved as is done in human vision system, which recognizes objects; perceives depth; identifies different textures, curved surface, or a surface inclination by texture information and brightness information collectively called as textone. Therefore, the present approach is hybridization of syntactic and statistical approaches for texture-based segmentation and classification with artificial neural network (ANN) as segmentation and classifier tool. In this scheme, we have used first- and second-order statistical features of the texture-primitive cell for segmentation and classification. In contrast with the syntactic approach, instead of using rules and grammar to represent pattern in terms of sentences, we used analysis by synthesis method. The image is re-synthesized on the basis of classification data produced by ANN. The location and size of texture to be segmented and classified can be directly seen.[2]

K. Murphy et al. have done classification using two steps, First kNN classification is done and the data's are merged and again subjected to final kNN classification.[4]

VII. CONCLUSION

Initially, the clinical use of computer analysis of CT of the lungs did not reach much further than the quantification of emphysema, a direct consequence of its relatively simple detection on CT. Ongoing improvements in scanner speed and quality have broadened the field of applications. Currently, the emphasis lies on detection and analysis of pulmonary nodules. Several commercial systems for automated nodule detection have acquired FDA approval and research effort is shifting from detection to characterization and follow-up. In this field, industrial R&D efforts probably outweigh those of academic research.

Commercial workstations are now capable of automatic nodule volumetry and nodule detection. These workstations perform segmentation, but beyond complete lung segmentation, these segmentation techniques are not directly available yet for clinical use. Apart from the pulmonary nodule, the lungs may contain much more pathology. Segmentation, registration and further image analysis of each anatomical structure has been researched, as is evident from this survey, but has not reached the status of routine clinical use. Based on the survey carried the future work may be concentrated on arriving an incremental image pre-processing model and also, enhancement of Images through textural and morphological processing to accomplish early detection of lung cancer/tumor. Also research can be focused to 3-D imaging which has a better scope for nodule detection.

REFERENCES

[1] M. S. Ahmad, M. Shahid Naweed, M. Nisa "Application of texture analysis in the assessment of chest radiographs" *International Journal of Video & Image Processing and Network Security IJVIPNS* Vol: 9 No: 9

[2] Neeraj Sharma, Amit K. Ray, Shiru Sharma, K. K. Shukla, Satyajit Pradhan, and Lalit M. Aggarwal "Segmentation and classification of medical images using texture-primitive features: Application of BAM-type artificial neural network "*Journal of Medical Physics J Med Phys*. 2008 Jul–Sep; 33(3): 119–126.

[3] S A Patil and V R Udipi "Chest X-ray features extraction for lung cancer classification" *Journal of Scientific & Industrial Research* Vol.69, April 2010, pp. 271-277.

[4] K. Murphy, B. van Ginneken, A.M.R. Schilham, B.J. de Hoop, H.A. Gietema, M. Prokop "A large-scale evaluation of automatic pulmonary nodule detection in chest CT using local image features and k-nearest-neighbour classification" *Medical Image Analysis* 13 (2009) 757–770, 2009 Elsevier.

[5] Yang Yu, Hong Zhao "A Texture-based Morphologic Enhancement Filter in Two-dimensional Thoracic CT scans"*2006 IEEE*, Pages 850-855.

[6] Bram van Ginneken, Shigehiko Katsuragawa, Bart M. ter Haar Romeny, Kunio Doi, and Max A. Viergever "Automatic Detection of Abnormalities in Chest Radiographs Using Local Texture Analysis" *IEEE Transactions on Medical Imaging*, Vol. 21, No. 2, February 2002.

[7] Omar S. Al-Kadi, and D. Watson "Texture Analysis of Aggressive and Nonaggressive Lung Tumor CE CT Images" *IEEE Transactions on Biomedical Engineering*, Vol. 55, No. 7, July 2008.

[8] Binsheng Zhao, Gordon Gamsu, Michelle S. Ginsberg, Li Jiang, and Lawrence H. Schwartz "Automatic detection of small lung nodules on CT utilizing a local density maximum algorithm" *Journal of Applied Clinical Medical Physics*, Vol. 4, No. 3, Summer 2003.

[9] Wu CM, Chen YC. Texture features for classification of ultrasonic liver images. *IEEE Trans Med Imaging*. 1992;11:141–52. [PubMed]

[10] Miller P, Astley S. Classification of breast tissue by texture analysis. *Image Vision Comput.* 1992;10:277–82.

[11] Koss JE, Newman FD, Johnson TK, Krich DL. Abdominal organ segmentation using texture transform and Hopfield neural network. *IEEE Trans Med Imaging.* 1999;18:640–8. [PubMed]

[12] Xie J, Jiang Y, Tsui HT. Segmentation of kidney from ultrasound images based on texture and shape priors. *IEEE Trans Med Imaging*. 2005;24:45–57. [PubMed]

