Classification of Lobar Pneumonia by Two Different Classifiers in Lung CT Images

N.Deepika, P.Vinupritha and D.Kathirvelu

***Abstract*—Pneumonia is a lung disorder caused due to microbial infections. The study is an attempt to identify and classify pneumonia into several stages as mild, moderate and severe using Gray Level occurrence Matrix (GLCM) texture features. The study involves 30 subjects (10 mild, 10 moderate and 10 severe) suffering from mild, moderate and severe lobar pneumonia. The CT examination of lung was performed using Philips MX8000 IDT 16 slice CT scanner for all subjects and saved in DICOM format. The obtained images were subjected to median filtering for noise removal and normalisation was done using contrast stretching. Subsequently GLCM was applied to extract various texture features namely contrast, energy, maximum probability, variance, mean, skewness, entropy, standard deviation, autocorrelation, median, mode, cluster prominence, cluster shade, homogeneity and kurtosis. A neural network classification scheme was adopted to identify the various diseased groups. The results of post hoc test (tukey HSD) revealed that there exist statistically significant differences for the texture features namely contrast, energy, mean, standard deviation, autocorrelation and median at the level $p < 0.05$. The results of the study infer that the proposed method could be effectively used in diagnosis of pneumonia.**

***Index Terms*—Fuzzy c means, GLCM, Pneumonia, neural network**

I. INTRODUCTION

THE respiration mechanism is carried out by a pair of lungs and a series of air passages leading to the lung. The bronchioles further divide into alveolar duct which s finer branches. This alveolar duct further divides into alveoli, thin walled, grape shaped air sacs [1-3]. These alveoli are the functional units of gaseous exchange. The humans have a pair of spongy lungs located in the chest cavity formed by the ribs and are surrounded by chest wall, which is made up of ribs and muscles in-between the ribs [4].

N. Deepika is with Department of Biomedical Engineering, SRM Institute of Science and Technology, Kattankulathur-603203 (e-mail-deepikanagulan22@gmail.com)
P.Vinupritha is with Department of Biomedical Engineering, SRM Institute of Science and Technology, Kattankulathur-603203 (e-mail-vinupritha@gmail.com)
Dr. D Kathirvelu is with Department of Biomedical Engineering, SRM Institute of Science and Technology, Kattankulathur-603203 (e-mail-kathir297@gmail.com)

The actual exchange of gases in the human takes place in the alveoli in the lungs, where carbon dioxide goes out of the blood and oxygen from the air enters and binds with the haemoglobin in the blood. Human lungs are divided into right lung and left lung [5]. The right lung has three lobes: the upper, the middle and the lower lobe. The left lung has two lobes: the upper and lower lobe. The pulmonary circulation gives the blood supply to the lungs. Various abnormalities lead to lung diseases leads to improper functioning of the lungs. The disorders in lungs is termed as lung disease. Lung disease are classified into three different types airway disease, lung tissue disease and lung circulation disease [6]. Airway disease is due to narrowing of airways due to infection in the tubes that carry oxygen into and out of the lungs. Lung tissue disease causes inflammation of the tissues in the lungs making it difficult to expand fully. Lung circulation disease causes clotting or inflammation of the blood vessels affecting lungs ability to take up oxygen and release carbon dioxide. The most common lung disease include pneumothorax, asthma, bronchitis, lung cancer, pneumonia (lung infection), pulmonary embolus, chronic obstructive pulmonary disease (COPD) and pulmonary edema.

Reports estimate that 150.7 million new cases, among which 7-13% need to be admitted in hospitals [7]. Survey forecast 920 136 children are killed due to pneumonia under the age of 5. This accounts 16% of children death under 5 years old. Pneumonia is most prevalent in South Africa and sub-Saharan Africa [8]. It is observed that 95% of lung pneumonia cases are found in children in developing countries [9]. The pneumonia is the worldwide single largest infectious cause of death among children.

Pneumonia is a disease that causes inflammation in the alveoli (air sacs) in the lungs [10]. Pneumonia occurs either in one of the lung or in some cases it affects both the lung. Pneumonia is most commonly affected by virus, bacteria, fungi and by some other microorganisms. The symptoms of pneumonia start with a sign of typical cold and further signs includes difficulty in breathing, cough, fatigue and fever [11]. The area infected pneumonia is classified into bronchial pneumonia, lobar pneumonia and interstitial pneumonia [12]. Bronchial pneumonia is an infection that is spread all over the lungs, whereas lobar pneumonia is an infection in a lobe [13-14]. The bacterial and fungal pneumonia infections are treated by antibiotics. Pneumonia caused by virus uses some of the antiviral medications. Imaging of lung pneumonia are performed using chest x-ray, CT scan imaging and lung ultrasound imaging. The most preferred type of

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pneumonia diagnosis is CT scan imaging since it is painless, most accurate and non-invasive method. The study involves 30 subjects mild (10 images), moderate (10 images) and severe (10 images) of pneumonia patients. An attempt to identify the pneumonia affected subjects and segment the infected region and to extract the various GLCM texture features and subsequently classify the infected individuals as mild, moderate and severe cases using two classifiers (neural network and SVM).

The rest of the paper is organized as follows. Section II describes the materials and methods. Section III discusses the result. At last, Section IV concludes the paper.

II. MATERIALS AND METHODS

A. *Study population*

The adults of both male and female aged more than 20 years are taken as subjects. The pneumonia infected subjects are examined under CT scan and various slices of images of every individual subject are obtained.

B. *Selection of images*

The block diagram of the proposed method is shown in Fig. 1. Philips MX8000 IDT 16 slice CT scanner machine is used to obtain CT images of different patients are collected in DICOM format from Saveetha Medical College and Hospital (SMCH). The subjects are selected based on categorised lung lobar pneumonia infection into mild, moderate and severe under the guidance of radiologist from SMCH hospital. 16 slices of images for single subjects is obtained. The acquired images are digitalised at 1024x768 pixels and are stored in digital computer.

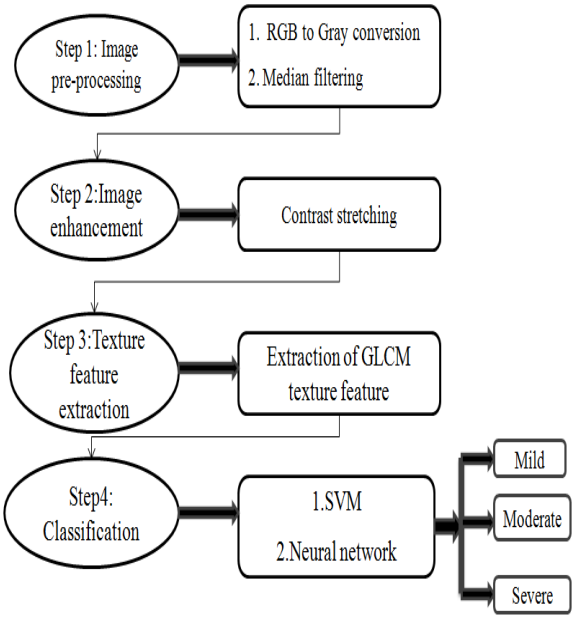

Fig. 1. Schematic diagram describing the classification of mild, moderate and severe pneumonia.

C. *Image pre-processing*

The stored digitalised CT scan images of pneumonia infected patients was transformed into gray scale image and median filter is used to remove noises efficiently and to make image smooth for segmentation. Further image enhancement is done to brighten up the images.

D. *Feature Extraction*

Texture feature extraction is the next step after image segmentation. Various GLCM texture features are extracted from segmented pneumonia region from CT scan images. The following features were extracted (a) Contrast, (b) Energy, (c) Maximum probability (MP), (d) Variance, (e) Mean, (f) Skewness, (g) Entropy, (h) Standard deviation, (i) Autocorrelation, (j) Median, (k) Mode, (l) Cluster prominence, (m) Cluster shade, (n) Homogeneity, (o) Kurtosis

E. *Classification*

1. Neural network

Neural Network classifier is used to differentiate images into three different classes. Different layers are used in neural networks for analysing and learning data. Neural network is composed of three sections: an input layer, hidden layer and an output layer. Each hidden layer in neural networks is to detect patterns. The number of layers decides the pattern with accuracy. The study involves one input layer which is texture features given to 5 hidden layers and one output layer. The input set is compared with the target set. The target set for mild (1 0 0), moderate (0 1 0) and severe (0 0 1).

2. Multiclass Support Vector Machine (SVM)

Support vector machine is a supervised machine learning algorithm. Each data items are plotted as a point in n-dimensional space. Where the x-axis and y-axis be, the features extracted. Where the x-axis and y-axis be, the features extracted. The hyper plane is drawn which gives information to which class the data items belong to. The best hyper plane is that has maximum margin from the classes. The margin is the distance between the hyper plane and the closest data item.

III. RESULT

The digitised image is applied with pre-processing techniques as described in section materials and methods have been applied to microscopic images of mild lobar pneumonia, moderate lobar pneumonia and severe lobar pneumonia. The processed image of mild pneumonia is shown in Fig. 2.

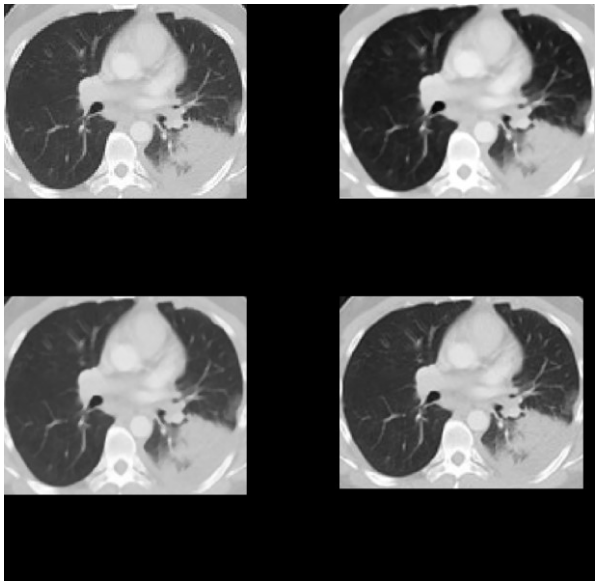

Fig. 2. Mild pneumonia (a) input image (b) gray scale image (c) median filtered image (d) enhanced image

The processing of image involves gray scale conversion, filtering by median filter, enhancement and GLCM texture feature extraction of mild pneumonia microscopic images. The processed image of moderate pneumonia is shown in Fig. 3. The processing of image involves gray scale conversion, filtering by median filter, image enhancement and GLCM texture feature extraction of moderate pneumonia microscopic images. The processed image of severe pneumonia is shown in Fig. 4.

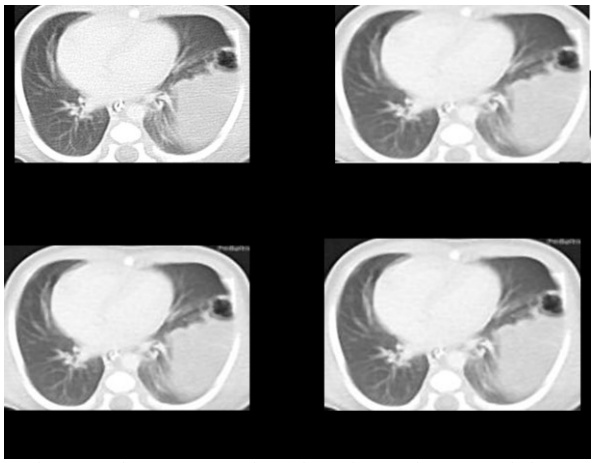

Fig. 3. Moderate pneumonia (a) input image (b) gray scale image (c) median filtered image (d) enhanced image

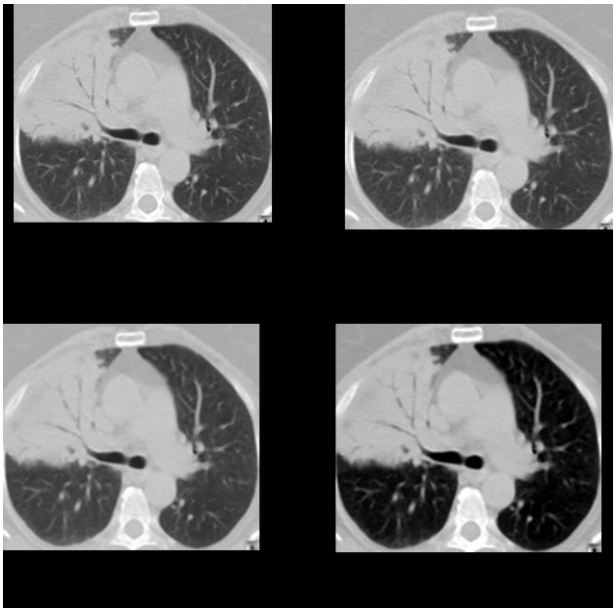

Fig. 4. Severe pneumonia (a) input image (b) gray scale image (c) median filtered image (d) enhanced image

The various texture features were extracted for mild, moderate and severe pneumonia are listed in Table I. This table also gives the overall values and f- values for various texture feature. The six among fifteen extracted texture values show major variation among mild, moderate and severe pneumonia cases. The six features include contrast, entropy, autocorrelation, median, cluster shade and kurtosis. The resultant six texture features are given as input for the neural network classifier. The multiclass SVM classifier differentiates mild, moderate and severe pneumonia based on the hyper plane constructed. The accuracy for neural network and SVM classifiers are given in the following Table 2. The accuracy for back propagation neural network classification is 96% and the accuracy for multiclass Support Vector Machine classifier is 86%. Thus, neural network classifier is better when compared to modern support vector machine classifier.

TABLE I
FEATURE EXTRACTION OF MILD, MODERATE AND SEVERE PNEUMONIA

Characteristic	Mild	Moderate	Severe	Overall	F-value	Sig
Contrast	1.43 ± 0.45^{a}	1.47 ± 0.58^{a}	2.55 ± 1.02^{b}	1.81 ± 0.87	7.732	$< 0.01^{**}$
Energy	0.86 ± 0.7	0.64 ± 0.69	0.34 ± 0.39	0.61 ± 0.63	1.829	NS
Max probability	0.91 ± 0.64	0.91 ± 0.57	1 ± 0.72	0.94 ± 0.63	0.58	NS
Variance	0.02 ± 0.02	0.16 ± 0.3	0.1 ± 0.08	0.1 ± 0.18	1.642	NS
Mean	0 ± 0^{a}	0.18 ± 0.29^{ab}	0.36 ± 0.15^{b}	0.18 ± 0.24	8.806	$< 0.01^{**}$
Skewness	6.92 ± 2.3^{a}	5.53 ± 1.37^{a}	0.73 ± 0.61^{b}	4.39 ± 3.1	41.951	$< 0.01^{**}$
Entropy	2.59 ± 0.85^{a}	2.6 ± 1.04^{a}	4.4 ± 1.21^{b}	3.2 ± 1.33	9.985	$< 0.01^{**}$
Standard Deviation	0.14 ± 0.11	0.37 ± 0.36	0.43 ± 0.32	0.31 ± 0.31	2.908	NS
Autocorrelation	1.71 ± 1.22^{a}	11.04 ± 1.85^{b}	21.16 ± 2.88^{c}	11.3 ± 8.33	215.09	$< 0.01^{**}$
Median	0 ± 0^{a}	0.1 ± 0.07^{ab}	0.21 ± 0.18^{b}	0.1 ± 0.14	8.543	$< 0.01^{**}$
Mode	0 ± 0^{a}	0.57 ± 0.29^{b}	0.46 ± 0.29^{b}	0.34 ± 0.34	15.854	$< 0.01^{**}$
Cluster prominence	205.59 ± 4.41^{a}	2704.1 ± 144.62^{b}	2059.1 ± 244.12^{c}	1656.26 ± 1088.68	626.752	$< 0.01^{**}$
Cluster shade	20.91 ± 3.17^{a}	222.3 ± 10.69^{b}	226.3 ± 25.31^{b}	156.5 ± 98.74	540.935	$< 0.01^{**}$
Homogeneity	20.91 ± 2.42^{a}	0.85 ± 0.5^{b}	0.96 ± 0.6^{b}	7.57 ± 9.7	617.756	$< 0.01^{**}$
Kurtosis	63.17 ± 3.5^{a}	28.72 ± 5.73^{b}	2.61 ± 1.59^{c}	31.5 ± 25.52	581.415	$< 0.01^{**}$

TABLE II
THE ACCURACY OF NEURAL NETWORK AND SVM CLASSIFIERS

CLASSIFICATION	ACCURACY
Neural network	96%
Support vector machine	86%

IV. CONCLUSION

Pneumonia is an inflammatory condition in the lung affecting primarily the small air sacs known as alveoli. Pneumonia is an infection in either one or both the lungs. This causes difficulty in breathing and cause severe respiratory problem. Pneumonia in lungs are classified into bronchial and lobar pneumonia. Lobar pneumonia in lungs causes difficulty in breathing due to bacterial accumulation in bloodstream, fluid accumulation around the lungs (pleural effusion) that leads to changes in the textural features of the lungs. Therefore, there will be change in texture features of mild, moderate and severe pneumonia. In the proposed method, the pneumonia affected CT images are collected from different patients and extracting the textural features from the pre-processed pneumonia affected images. Thus, there will be changes in textural features when compared with mild, moderate and severe pneumonia. Based on this changes in texture features pneumonia can be classified into mild, moderate and severe pneumonia using different classifiers. Labelling a person as pneumonia requires radiologist advice. By this approach a person with pneumonia CT scan images can be classified into mild, moderate and severe without the knowledge of the radiologist. As earlier study presents an application of Gray Level co-occurrence Matrix (GLCM) to extract second order statistical features for motion estimation of images. This

used four GLCM texture features such as Angular Second Moment (ASM), correlation, inverse difference moment and entropy are extracted. The results show that these texture features have high accuracy, requires less computational time and hence efficiently used for real time pattern recognition applications [17]. An earlier study in comparing normal lung and diseased lung using GLCM texture properties and differentiating it based on the texture properties [18]. An earlier study in classifying normal and abnormal lung CT images using GLCM texture features such as contrast, energy, homogeneity and correlation that used only sets of two normal and two abnormal images which failed to show accuracy in classification [19]. In the present study, pre-processing pneumonia CT scan images and differentiating it based on 15 various GLCM texture features on different slices of images from 30 different subjects. Based on this texture feature result we can classify the CT scan images into mild, moderate and severe pneumonia.

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