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A Novel Hybrid Framework for the Detection and Risk Severity of Chronic Obstructive Pulmonary Disease

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***Abstract* -The COPD is a limitation in airflow and is not completely reversible, and affects up to one quarter of adults with 40 or more years. The risk factors of COPD typically include tobacco smoke, masculine gender, exposure to chemicals and dusts, asthma, air pollution and genetic reasons as rare hereditary deficiency of α1-antitrypsin. The COPD leads to death if it is treated properly. So if it recognized earlier and more correctly, the life span of affected people will increase. Thus, in this paper, new framework based on block variation of local correlation coefficients (BVLC) and support vector machine (SVM) is suggested to identify chronic obstructive pulmonary disease in CT images. The experiments on benchmark database clearly proven that recommended approach is suggestively good in terms of accuracy and time.**
***Keywords:*Chronic Obstructive Pulmonary Disease, Block Variation of Local Correlation Coefficient, Support Vector Machine**

I. INTRODUCTION

COPD is lung disease and is described by airflow limitation and it occurs due to the damage or inflammation in lung tissue and is caused by and is bronchitis and bronchiolitis. COPD decrease the air passing through air passing and it may leads to death due to the developing of lung cancer, heart disease, etc. It is reported by world health organization that COPD will develop as 5th ranked disease and will become a 3rd reason for the death of people. The most reason for COPD is smoking. Though COPD is incurable and progressive, early prediction of COPD and appropriate treatment may lengthy the life of people. Though COPD is identified by using some symptoms like increased shortness of breath, tightness in chest, frequent coughing, wheezing, etc., these symptoms may be related with some other diseases also. Thus, physicians go for some other tests and the basic examination for COPD is pulmonary function test. However it is time consuming, manual and less accuracy. By analyzing the radiographic features of X ray, CT images of lung also we can able to identify the COPD. In specific, CT image of lung provides high radiographic features of lung and its air path. Nowadays researchers in medical domain focusing on computer aided diagnostic (CAD) system and in line with this, researchers performed numerous research in the domain of COPD because of accuracy of disease prediction using the CAD systems are very high than the manual analysis by the physicians. The detailed review on COPD is described as follows.

Author Name	Description of the Paper	Methods used
Abiyev*et al.*, [1]	Convolutional neural networks (CNNs) are employed for diagnosis of chest diseases.	convolutional neural networks, back propagation neural networks
Bansal, Atul, RavinderAgarwal, and R. K. Sharma [2]	The system predicts OLD. 2D Gabor filter and Support Vector Machine based iris recognition system has been combined with iridology for implementation of proposed system	2D Gabor Filter, Support Vector Machine
Grønnesby, Morten, *et al.*,[3]	A machine learning based approach for identifying crackles in lung sounds recorded using a stethoscope in a large health survey	Support Vector Machines (SVM), K-Nearest Neighbor (KNN), Adaptive Boosting and Decision Trees
Andrés-Blanco, Ana M., *et al.*,[4]	It Assess the influence of suffering from COPD in the performance of an oximetry-based screening test for moderate-to-severe OSAS, both in hospital and at home.	Regression based Multi-Layered Perceptron, Artificial Neural Network
Swaminathan, Sumanth, *et al.*,[5]	A machine learning-based strategy for initial discovery of exacerbations and subsequent triage. It uses physician opinion in statistically and clinically comprehensive set of patient cases to train a supervised prediction system.	support vector machines, logistic regression, Naive Bayes, KNN, gradient boosted and ensemble decision tree methods
Serbes*et al.*,[6]	The respiratory sounds are categorized into 4 classes in existence of various noises (motion artifacts, coughing, talking heart and intestinal sounds) using SVM classifier with Radian basis function kernel.	Support Vector Machine, Radial Basis function
Saleh, Lokman, *et al.*,[7]	Machine learning approaches to increase prediction accuracy in COPD. Authors compared three of most general machine learning algorithms (decision tree, naive Bayes and Bayesian network) based on ROC metric.	decision tree, naive Bayes and Bayesian network
Moghadas-Dastjerdi, Hadi, *et al.*, [8]	Naive Bayes classifier is proposed to accurately assess COPD severity	Naive Bayes classifier
Belchi, Francisco, *et al.*,[9]	Introduced new analytical tool based on persistent homology that extracts quantitative features from chest CT scans to describe geometric structure ofairways inside lungs.	Topological Data Analysis

Peng, Yuanyuan, and Changyan Xiao [10]	An oriented derivative of stick filter is suggested by merging the direction information to increase existed DoS filter.	Oriented Derivative of Stick (ODoS)
Hoff, Benjamin A., *et al.*,[11]	Parametric response mapping of paired CT lung images has been shown to increase phenotyping of COPD by allowing for visualization and quantification of non-emphysematous air trapping component, referred to as functional small airways disease (fSAD).	Parametric Response Mapping, 3D PRM
Das *et al.*,[12]	Machine learning has been magnificently used in automated interpretation of pulmonary function tests for differential diagnosis of obstructive lung diseases. Deep learning models such as convolutional neural network are state-of-the art for obstructive pattern recognition in CT	Convolutional Neural Network
Kanwade, Archana, and V. K. Bairagi [13]	Support Vector Machine based approach is explained for the classification of COPD disease	Support Vector Machine
Kimura, Toru, *et al.*,[14]	Deep learning algorithm is utilized	Deep Learning algorithms
Fernandez-Granero*et al.*,[15]	In this study, 16 patients were telemonitored at home during six months. Respiratory sounds were recorded daily with an electronic sensor ad-hoc designed. In order to enable an automatic prediction of symptom-based exacerbations, recorded data were used to train and validate a decision tree forest classifier.	discrete wavelet transform, Fast correlation-based filter, Decision Tree forest
Spathis, Dimitris [16]	This study examined the clinical decision support systems in healthcare, in particular about the prevention, diagnosis and treatment of respiratory diseases, such as Asthma and chronic obstructive pulmonary disease.	Naïve Bayes, Logistic Regression, Neural Network, SVM, K-Nearest Neighbor, Decision Tree, Random Forest
Caliskan, SerifeGokce [17]	This study aimed to investigate nonlinear parameters such as largest Lyapunov exponent (LLE) and correlation dimension of electro-dermal activity signals recorded from healthy subjects and patients with COPD	Shapiro–Wilk normality test, one-way analysis of variance (ANOVA), Bonferroni post-test and Kruskal–Wallis non-parametric test

However, still there is stagnation in accuracy and time cost of existing systems for COPD identification or classification of various stages of COPD. The victory of computer aided system is fully depends on the election of accurate segmentation approach, selection of effective features for representing the region of interest and effective classification mechanism. Otherwise, the CAD systems not capable to recognize the COPD in its initial stage and may fail to classify the stages correctly and it leads to inadequate treatment options and it finally ends in death of diseased person. Although lot of research has been reported in the domain of COPD.This paper suggests a novel CAD to identify the COPD in the CT images of lung. The suggested system is more effective in terms of accuracy, storage and time cost. The suggested approach comprises of 3 steps and is segmentation, feature extraction and classification for classifying the CT images of lung into various categories of disease centered on feature vector.In the literature, both automatic and semi-automatic segmentation methods like region or contour based approaches has been studied in huge numbers for segmentation. Each method has its own pros and cons. In the proposed study, Ostu's method is employed for segmentation in which clustering based image thresholding is approached. The employed Ostu'salgorithm is perfectly fit and attains high accurate segmentation result for the problem of COPD.Detection on COPD from CT image based on texture features offer novel intuitions to the development of more accurate and consistent CAD system. In the literature, number of texture descriptors has been recommended by the researchers in the domain of COPD. But, their efforts on identifying the appropriate texture feature for the analysis of COPD in CT images of lung is ends in less accuracy due to the reason of capturing either global or local level texture, less proficient of representation of variety of textures in an image and so on. In this study, we used an efficient texture feature named block variation of local correlation coefficients (BVLC) [18,19].The rest of paper is deliberated as follows. Image feature extraction is deliberated in section 2. In Section 3, Experiments and analysis are reported and Sections 4 discusses the conclusion.

II. PROPOSED METHODS

A. BVLC: BVLC [18, 19] is difference between maximum and minimum of local correlation coefficients corresponding to four orientations $(0^\circ,90^\circ,45^\circ,\text{-}45^\circ)$ in block. This feature measures texture smoothness using variations of local correlation coefficients in image blocks as in equation (4).

$$\rho(k,l) = \frac{\frac{1}{M^2}\sum_{(x,y)\in B} f(x,y)f(x+k,y+l) - \mu_{0,0}\mu_{k,l}}{\sigma_{0,0}\sigma_{k,l}} \quad (1)$$

Where B is a block of size M x M and $\mu_{0,0}\mu_{k,l}$ is the local mean, and $\sigma_{0,0}\sigma_{k,l}$ is the local standard deviation. The (k,l) represents a pair of horizontal shift and vertical shift associated with four orientations $(0^\circ,90^\circ,45^\circ,\text{-}45^\circ)$. Later shifting M x M windows in each of 4 directions, calculate p(0,1), p(1,0), p(1,1), p(1,-1) then BVLC is calculated as exposed in equation (5).

$$BVLC^d(l) = \max_{\Delta(k)\in O_4}[\rho^k(l,\Delta(k))] - \min_{\Delta(k)\in O_4}[\rho^k(l,\Delta(k))] \quad (2)$$

Where $\Delta(k) = (\Delta_x(k), \Delta_y(k))$ represents for shift in one 4 directions and $O_4 = \{(-k,0), (0,-k), (0,k), (k,0)\}$

III. EXPERIMENTS AND ANALYSIS

Inorder conduct the experiments, we collected CT images from the Raja Muthiya Medical College Hospital of Annamalai University, India. The database consists of 456 CT images of various classes of lung disease with ground

truth. The BVLC [19] feature is computed for each image in database and are stored in feature vector database. The extracted features are classified into various stages of lung disease using support vector machine [20]. Five-fold cross validation is performed in the validation phase.The efficacy of existing and proposed system is computed using the statistical measures called sensitivity and specificity. The sensitive measures true positive rate and is demarcated as proportion of real positives which are properly identified. Whereas specificity is true negative rate which is proportion of actual negatives which are correctly identified. It is clearly confirmed from ROC curve that proposed approach out performs very well and attains higher classification rate then the existing approaches [1, 8]. However, theclassification rate of proposed approach is slightly lesser than existing approach [1]. But such a mild decline in the classification is acceptable because [1] takes more time cost than the proposed approach.

TABLE I ASSESSMENT OF THE PROPOSED AND EXISTING FRAMEWORK IN TERMS OF ACCURACY AND TIME COMPLEXITY

Method	Time in seconds	Accuracy
Proposed	2.43	95.21
Abiyev*et al.,*	6.21	95.99
Moghads*et al.,*	3.95	87.12

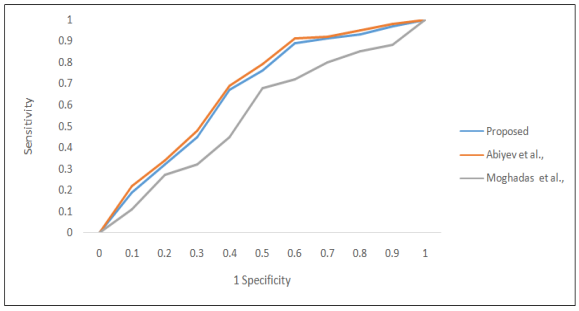

Fig. 1 ROC curves attained in the classification for the proposed, Abiyev*et al.,* and Moghads*et al.,*appraoch

IV. CONCLUSION

Chronic Obstructive Pulmonary Disease (COPD) is one of vital factors contributing to majority of lung diseases worldwide. So, there is necessity for development of some inexpensive and invasive automated technique for accurate detection of different stages of COPD. In this paper, Ostu's algorithm is used for accurate segmentation, block variation of local correlation coefficients (BVLC) is used as texture feature and support vector machine is used for efficient classification. The experimental results confirmed that the proposed combination of techniques produces significant raise in accuracy and time cost. And this combination of methods will be of great help in less advanced countries where there is severe lack of radiologists.

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