Categorization of obstructive respiratory disorder on the basis of spirometric tests

Mrs. Sheetal N. Ukunde[1], *DBACER* , Nagpur Sheetal_alisha@yahoo.com

Mr Rahul Batra2 *DBACER* , Nagpur rahul.batra55@gmail.com

Mrs .Sukeshini P. Balwir DBACER Nagpur swatibalwir8@gmail.com

Abstract- Increased environmental pollution, global warming, indoor contamination and smoking habits which are leading to air pollution which is nothing but the decreased amount of oxygen in the air and increased amount of carbon di oxide. This results into the increased lung diseases which are reducing the life expectancy. Lung diseases can be found out by using different tests one of which is, a noninvasive test, called spirometric test. This paper revels technique used to detect obstructive respiratory disorder on the basis of results of spirometric tests. It uses database analysis results on the results extracted from Spirometer for predicting the possibility of diseases like asthma, Bronchitis and emphysema which have similar symptoms

Keywords: – COPD (Chronic Obstructive Pulmonary Disease), emphysema, expert systems, FVC (forced vital capacity), FEV1, fuzzy logic, knowledge-base, membership function, rule-base,

1. Introduction

The air pollution, indoor contamination and smoking habits are leading to the increased lung diseases in spite of that Increased life expectancy, requires methods to classify the different Lung diseases, The chronic obstructive pulmonary diseases occupies 6th position among the main mortality cause in world[1] so recently heart lung and blood institute recommended that research on new technologies to improve non invasive tests should be on priority.

Following that first all the lung diseases are studied and it is found that, their are two main types of lung diseases.

2. Types of lung Diseases

2.1 Restrictive respiratory Diseases (Lung tissue diseases):

These diseases affect the structure of the lung tissue. Scarring or inflammation of the tissue makes the lungs unable to expand fully ("restrictive lung disease"). It also makes the lungs less capable of taking up oxygen (oxygenation) and releasing carbon dioxide.

People sometimes describe the feeling as "wearing a too-tight sweater or vest" that won't allow them to take a deep breath. They include

i. Pulmonary fibrosis

ii. Sarcoidosis

2.2. Obstructive Respiratory diseases (Airway diseases):

These diseases affect the tubes (airways) that carry oxygen and other gases into and out of the lungs. These diseases cause a narrowing or blockage of the airways. People with airway diseases sometimes describe the feeling as "trying to breathe out through a straw." They include

i. Asthma
ii. Chronic bronchitis
iii. Emphysema
iv. Pulmonary fibrosis

out of these we are targeting on the obstructive lung diseases like Asthma, Chronic Bronchitis and emphysema. As these diseases have quite similar symptoms so hard to discriminate between them depending on the availability of the data which.

3. Literature Review

According to Marco Parvis, *Senior Member*, *IEEE*, Carlo Gulotta, and Roberto Torchio, a correct diagnosis of asthma, bronchitis, and emphysema can be reliably obtained by means of clinical, radiological, and functional assessment involving several tests, but this would greatly increase the overall cost and time of the procedure required for the diagnosis. The aim of this work was, therefore, to verify if a reasonable and accurate prediction could be obtained by combining the results of different simple spirometric data, which are collected before and after pharmacological bronchodilation. Several different tests have been proposed to discriminate between the three pathologies [2]–[4]. After some tests, the authors decided to use four of the tests most commonly found in literature. Two tests concern lung parameters: the residual lung volume(*RV*) and the transfer lung factor for carbon monoxide (*TLCO*).The other two tests are related to the change of two respiratory parameters: forced expired volume in 1s and the specific airway conductance , before and after inhalation of a broncodilator (200 mg of salbutamol). All the test results were normalized to the standard predicted results accordingto the European Respiratory Society (ERS) recommendations[2]

This paper has presented a possible procedure to obtain such a discrimination which is based on four simple respiratory tests. The four test results are sent to three MLPs trained to recognize the three pathologies. The network outputs are then combined to define the diagnosis. Two different methods have been presented. The most interesting results are obtained with the method which estimates the evidence index of each pathology and its uncertainty. Starting from these values, each patient is tagged as either not classifiable or affected by one of the three pathologies. The classification is performed by employing a set of thresholds that can be chosen either to reduce the number of erroneous diagnoses, at the expense of a greater number of unclassified patients, or to reduce the

number of unclassified patient set the expense of a greater number of erroneous diagnoses. The proposed algorithm has been trained on a population of 55 patients and tested on another population of 103 patients. Depending on the threshold choice, an error rate in the range of 4% to 10% has been obtained in the control set with a rate of unclassified patients in the range of 50% to 22%. A simple program has been developed which implements the algorithm and can be used to quickly estimate the patient's situation and decide if other tests should be performed. An analysis of the performance difference within the training and control sets suggests that even better results could be obtained by enlarging the training set to better represent the different kinds of pathologies. The authors are collecting new data to verify this possibility and will update the results as soon as a reasonable number of new examples becomes available.[2]

Acording to Aimé Lay-Ekuakille, *Member, IEEE*, Giuseppe Vendramin, and Amerigo Trotta, *Member, IEEE* Analysis of lung mechanic impairment is the first important step of diagnostic procedures in lung diseases. According to the guidelines of the European Respiratory Society 1993 [3], the diagnostic procedures of lung mechanics disturbances include spirometry (VC, FEV1), the registration of maximal expiratory flow volume loop and the calculation of maximal expiratory flow rates (PEF, MEF50, MEF25), and the measurement of functional residual capacity (FRC) and airway resistance (Raw) with whole body plethysmography. Estimation of static lung compliance is needed (Cst) especially in the interstitial lung diseases. From a theoretical point of view, the ventilation disturbance of the lung is a result of impairment of elastic and/or non-elastic resistances of the respiratory system. For these reasons two important methods, such as spirometry and body plethysmography, are very often used. We understand spirometry to be the first step in the analysis of lung mechanic disturbances, but this must be very often supplemented and verified by bodyplethysmography. These two methods are complementary and neither one can be replaced by the another. *The advantage of spirometry is the relative exact measurement of bronchial obstruction with relatively inexpensive equipment. The disadvantage is the necessity of very good cooperation* of the proband during testing of maximal forced expiration. The spirometric equipment for ventilation measurement is divided into two groups.

The volumeter for direct estimation of lung volumes belongs to the first group of spirometers. This type of Spirometer is very frequently used in hospitals and in outpatients' clinics.

The aim of the study was to analyze thoracic electrical impedance topographic (EIT)measurements accomplished under conditions comparable with clinical situations during artificialventilation. Multiple EIT measurements were performed in pigs in three transversethoracic planes during the volume controlled mode of mechanical ventilation at various tidal volumes(VT) and positive end-expiratory pressures (PEEP).The current study showed that changes in and lungvolume (induced by different PEEP levels) during artificial ventilation under clinically comparable conditions can be identified by derived EIT images and quantified in terms of the tidal amplitude and the minimum value of the impedance change. An increase in the tidal amplitude and the minimum value of the impedance change with and PEEP, respectively, was established in all studied thoracic planes. An increase in PEEPduring ventilation with constant led to a redistribution of the ventilated gas preferentially to the caudal lung regions[5]

Another study by Laura Poanta, Daniel Rusu reflected on the spirometric tests on smokers.

Half of our group of current smokers with the presence of chronic productive cough seems to be an independent risk factor for the development of chronic obstructive pulmonary disease (COPD) in current smokers. Stage 0 disease, or sub-clinical COPD, correlates with the risk of further developing COPD. Spirometry is indicated when a person presents with respiratory symptoms. The aim of this study was to investigate the correlation between spirometry and symptoms in a group of current smokers. Methods: thirty eight men and twenty women known as current smokers and presenting with respiratory symptoms were recruited. Respiratory symptoms were: dyspnea, chronic productive cough, and wheezing. A non-smokers control groupwas also recruited, age and sex matched. Impaired respiratory function, correlated with obstructive lung disease, as stated in current guidelines, was defined as FEV1/VC ratio <0.70. The results were analyzed using SPSS 10 for Windows; data are reported as mean, standard deviations and standard errors. The statistical significance was given by a p value < 0.05. Results from the total of fifty eight patients with respiratory symptoms, 55% had spirometric changes (FEV 1/VC ratio <0.70). Lower age, female gender, higher body mass index (BMI) and smoking index were related to significant respiratory symptoms despite an FEV (1)/VC ratio of >/=0.70. The most common problem in the quality assessment was an insufficient exhalation time. There were statistically significant differences ($p<0.05$) between men and women in our group regarding the correlation between symptoms and spirometry, especially when it comes to chronic cough and dyspnea, women having more often normal spirometric results, with mild or moderate symptoms. Conclusions: Half of our group of current smokers with symptoms had their suspected diagnosis confirmed with spirometry. Our data indicate that female gender, smoking index, higher BMI and shorter exhalation time increase the risk of being diagnosed with COPD without fulfilling the spirometric criteria for the disease. On the other hand, smokers who complain of this

symptom should be regarded as being at high risk for the development of COPD, and should be closely monitor zed.

Patients with smoking-related symptoms should be offered spirometry as they may benefit from symptom-relieving treatment.[6]

In diagnosis of COPD (Chronic Obstructive Pulmonary Diseases), spiromerty is an important

"Pulmonary Function Testing" in the medical evaluation of patients. Spirometric measurements FVC & FEV1 are very important to control the treatment, but some difficulties such as incompleteness, inaccuracy and inconsistency are

encountered during the test. "Fuzziness in Spirometry" is very important “real-world problem”. Even if it is almost impossible to find ideal mathematical equations, ideal prediction formulas and ideal propositions defining the behaviors formulated ideally satisfying the real-life, it is possible to define inexact medical information and findings as fuzzy sets. Furthermore, because of collected data just lying on the border-line cannot be strictly or clearly defined either "normal" or "abnormal", the physicians may misinterpret some criteria or indications. For such kind of reasons, it is needed a formal model of distinguishing COPD group diseases (chronic bronchitis, emphysema and asthma) by using fuzzy theory and to put into practice a “fuzzy rule-base”. Purpose of this study is to construct a fuzzy rule-base model for designing a “COPD Diagnosing Fuzzy Expert System by Classifying Spirometric FVC Plots”. [7]

4. Lung Function Tests

Lung Function Tests measures how much air you can breathe in and out, how fast you can breathe air out, and how well your lungs deliver oxygen to your blood. The main test for COPD is spirometry (spi-ROM-eh-tre). Other lung function tests, such as a lung diffusion capacity test, also may be used

4.1 Spirometry

This is a painless test, During this test technician will ask you to take a deep breath in. Then, you'll blow as hard as you can into a tube connected to a small machine. The machine is called a spirometer. The machine measures how much air you breathe out. It also measures how fast you can blow air out.

5. Analysis

The output graph of spirometer is as shown in figure1 and the numerical output is as shown in figure2 These numerical values are analysed on the basis of figure 3.The step by step code is written in MATLAB which will automatically predict the possible disorder on the basis of authenticated references which will help Doctor to diagnose faster. .

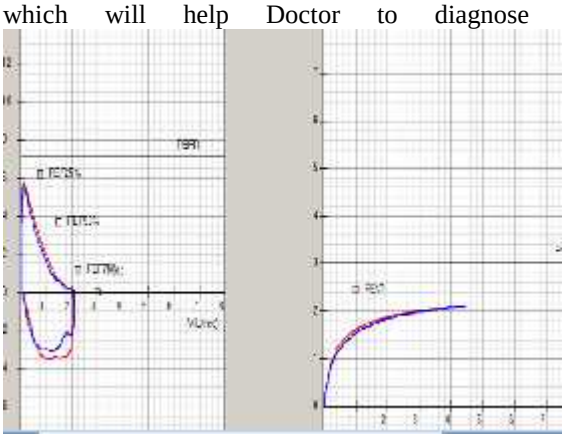
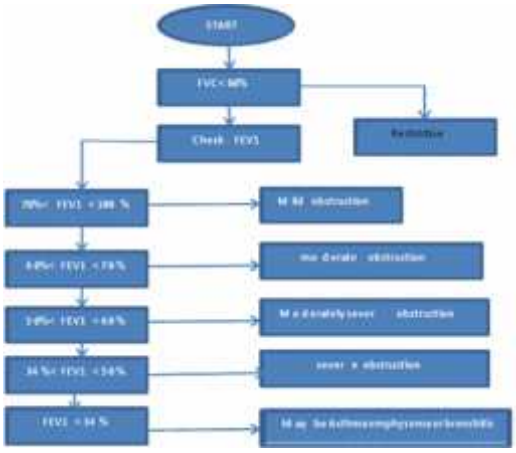


Figure1

Figure2



Flow diagram

The theorotical values of all the parameters such as FEV, FVC, FEV1 etc can be found out using the formulas given below which are the ideal values of the person

For Men

FVC = (0.0576 x height) - (0.026 x age) - 4.34 (SD: ± 0.61 litres)

FEV1 = (0.043 x height) - (0.029 x age) - 2.49 (SD: ± 0.51 litres)

For Woman

FVC = (0.0443 x height) - (0.026 x age) - 2.89 (SD: ± 0.43 litres)

FEV1 = (0.0395 x height) - (0.025 x age) - 2.60 (SD: ± 0.38 litres)

5.1 Software

The Spirometric Graphs Analysis: The graphs obtained from the patients diagnosed with particular diseases are fed to database and analyzed by

- The Spirometric Graphs Analysis: The graphs obtained from the patients diagnosed with particular diseases are fed to database and analyzed by techniques like line detection along with neural processing.
- Line detection during the analysis of the spirometric graphs and neural processing for the categorizing the range in which the disease lies.
- Finally Algorithm to compare the current sample with the result of analyzed data with disorders, will

be written in MATLAB which will help the Doctor for faster diagnosis

Applications

- Spirometry can detect COPD long before its symptoms appear. so Faster diagnosis.
- Resulting in faster treatment leading to less recovery time.
- To limit the use of costly diagnostic methods
- As it is a non invasive test, less trouble to the patient

Figure 4 the GUI for selecting the file and showing the result

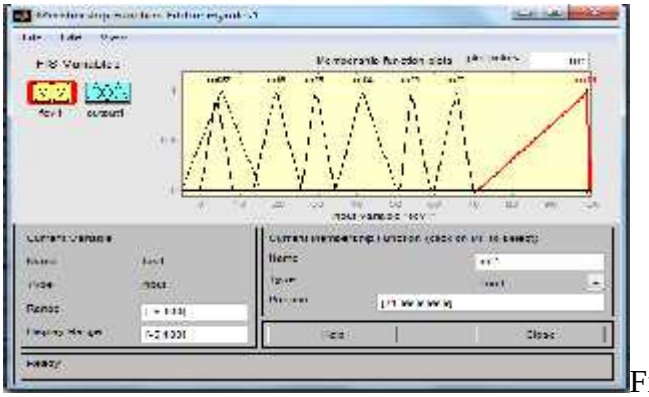


Figure5 The fuzzy outputsFigure

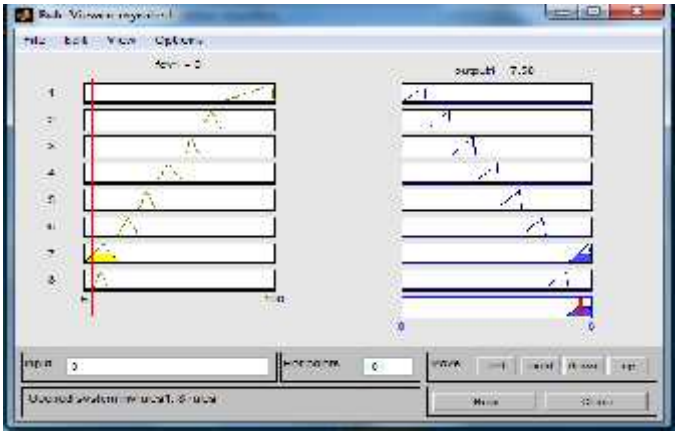


Figure 7 The Fuzzy Rulebase

6. Conclusion:

It is difficult to catagorize between the diseases with similar symptoms like Asthma Bronchitis and Emphysema when only functional, noninvasive tests like spirometry have to be employed to avoid unnecessary stress for the patients and to reduce the time required for diagnosis. This paper has presented a possible procedure to obtain such a discrimination which is based on the analysis of the spirometric tests database The categorization is done by using a fuzzy logic after analyzing around 1,500 samples of different diseases which supports the Doctor to diagnose the decease .

7. References

1. Illene Teixeira, Luiz G. M. Q. Nunes, and Pedro L. Melo, "Instrumentation for the analysis of airflow limitation by negative expiratory pressure technique", 32nd annual international conference of (*IEEE EMBSBuenos Aires, Argentina, August 31- Sep 4-2010.*
2. Marco Parvis», *Senior Member, IEEE, Carlo Gulotta, and obertoTorchio «*Mixed Neural-Conventional Processing to Differentiate Airway Diseases by Means of Functional Noninvasive Tests", *IEEE TRANSACTIONS ON INSTRUMENTATION AND MEASUREMENT, VOL. 50, NO. 3, JUNE 2001*
3. Aimé Lay-Ekuakille, *Member, IEEE*, Giuseppe Vendramin, and Amerigo Trotta, *Member, IEEE* "Spirometric Measurement Post processing: Expiration Data Recovery", IEEE SENSORS JOURNAL, VOL. 10, NO. 1, JANUARY 2010
4. Miller, MR; Crapo R, Hankinson J et al. General considerations for lung function testing. European Respiratory Journal 2005; 26 (1): 153–161
5. In´ez Frerichs,* G¨unter Hahn, and Gerhard Hellige "Thoracic Electrical Impedance Tomographic Measurements during Volume Controlled Ventilation-Effects of Tidal Volume and positive End-Expiratory Pressure" , *IEEE TRANSACTIONS ON MEDICAL IMAGING, VOL. 18, NO. 9, SEPTEMBER 1999*
6. Laura Poanta, Daniel Rusu, dL Dumitrascu Second department of Internal Medicine "The correlation between symptoms and spirometry in patients presenting with smoking related symptoms", department of Internal
7. Medicine, University of medicine and Pharmacy Iuliu Hatieganu Cluj Napoca
8. umit uncu1, etem koklukaya 2, aydin encsoy3,ovlyaguliannadurdiyew 4 "a fuzzy rule-base model for classification of spirometric fvc graphs in chronical obstructive pulmonary diseases" proceedings – 23rd annual conference – IEEE/EMBS Oct.25-28, 2001, Istanbul, TURKEY
9. Image processing by Gonsalvis
10. TanKokLiang1,ToshiyukiTanaka1,HidetoshiNakamura2,ToruShirahata3,andHiroakiSugiura3 "Anautomated3DEmphysemaExtractionMethodusingLung CT", SICE Annual Conference 2008 August 20-22, 2008, The University Electro-Communications, Japan
11. Stavroula G. Mougiakakou, Ioannis K. Valavanis, Nicolaos A. Mouravliansky, Alexandra Nikita, and Konstantina S. Nikita "DIAGNOSIS: A Telematics-Enabled System for Medical Image Archiving", Management, and Diagnosis Assistance"