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LabVIEW Based Analysis for Classifying Lung Diseases

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Abstract: The main aim of this project is to design and simulate LabVIEW Based Lung Analyzer. It offers flexibility, less cost, and user friendliness. The inspiratory and expiratory flow from the patient is given to the Spirometer. The pulmonary function data's collected from Spirometer is analyzed and displayed using virtual instruments. The analysis is based on pattern classification using Artificial Neural Network (ANN). The Backpropagation Algorithm is applied for classifying the lung diseases. Finally the diseases are diagnosed as Normal, Restriction and Obstruction. A virtual instrument for the diagnosis of the respiratory diseases is developed using the software package LabVIEW. Compared to traditional hardware-based instruments, the major advantage of virtual instrument is its flexibility. Flexibility in adding or removing various instruments or devices based upon alterations in established protocols enables to delve deeper into the physiological abnormalities associated with cardiopulmonary disorders. The LabVIEW software enables an intuitive Graphical User Interface (GUI) based on the principles of a virtual instrument. In effect, the computer is transformed into a VI designed specifically for cardiopulmonary assessment. LabVIEW offers the necessary flexibility in a graphical programming and data-driven environment.

Keywords- Spirometer, Artificial Neural Network (ANN), LabVIEW.

1. INTRODUCTION

Spirometry is essential pulmonary function test widely used in the diagnosis and management of respiratory disorders. In spirometry the flow of air inspired and expired is measured as a function of time using the equipment called spirometer. Spirometry provides useful information about overall respiratory system that can be fundamental in categorizing and staging pulmonary diseases. It can detect respiratory abnormalities and help to differentiate the various disease processes that result in ventilator impairment. The spirometer with pneumotachometer is a compact and versatile pulmonary function analyzer. The respiratory signals detected by the pneumotachometer are processed and used by the instrument's microcomputer to compute the respiratory parameters [1] [8][10]. The results are shown on the LCD display and can be printed. The display also shows the real time data and the graphical measurements of the respiratory parameters.

The development of Virtual Instrumentation (VI) technology has closely followed the growth of the computer industry. Representing a new generation of instrumentation, virtual instruments have been widely adopted by academic institutions, national laboratories, and corporate research and development centers for applications in manufacturing, automobile, aerospace, medical, and biomedical fields. A virtual instrument, in principle, is a computer based, software-driven instrument for test, measurement and process control purposes [3].The Fig 1 shows the block diagram representation of the project.

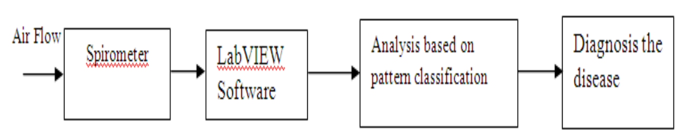

Fig1.Block diagram of the system

2. HUMAN RESPIRATORY SYSTEM

Respiratory system is a vital section in the human body. Supply of oxygen to the tissues and excretion of carbon dioxide occurs through respiration. Investigation about the

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performance of respiratory system is performed by the measurement of respiratory parameters. In this section, the respiratory mechanism, different respiratory parameters, different types of tests performed for measuring the instrument used are discussed in detail.

2.1 HUMAN RESPIRATORY PROCESS

The exchange of gases in any biological process is termed as respiration. To sustain life, the human body must take in oxygen, which combines with carbon, hydrogen, and various nutrients to produce heat and energy for the performance of the work. As a result of this process of metabolism, which takes place in the cells, a certain amount of water is produced along with the principal waste product, carbon dioxide. The entire process of taking in oxygen from the environment, transporting the oxygen to the cells, removing the carbon dioxide from the cells, and exhausting this waste product into the atmosphere is considered within the definition of respiration [2][3].

Unfortunately, no single laboratory test or even a simple group of tests is capable of completely measuring pulmonary function. The tests and instrumentation for the measurement of respiration can be divided into two categories. The first includes tests designed to measure the mechanics of breathing and the physical characteristics of the the lungs [6]; the second category is involved with diffusion of gases in the lungs, the distribution of oxygen and collection of carbon dioxide.

Mechanisms of breathing concern the ability to bring air into the lungs from the outside atmosphere and to exhaust air from the lungs. This ability is affected by the various components of the air passages, the diaphragm and associated muscles, the rib cage and associated musculature, and the characteristics of the lungs themselves. Tests can be performed to assess of these factors, but no simple measurement has been devised that can adequately and completely evaluate the performance of the breathing mechanism. A number of prominent lung parameters that are used clinically and in research in connection with mechanics of breathing are given below.

2.2 INSTRUMENT FOR MEASURING THE MECHANICS OF BREATHING

All the parameters dealing with the mechanics of breathing can be derived from measurement of lung volumes at various levels and conditions of breathing pressures within the lungs and the thorax with respect to outside air pressure, and instantaneous airflow.

The most widely used laboratory instrument for measurement of respiratory parameters is the spirometer. All lung volumes and capacities that can be determined by measuring the amount of gas inspired or expired under given set of conditions or during a specified time interval can be obtained by the use of spirometer. The only volume and capacity measurements that cannot be obtained by a spirometer are those requiring measurement of the gas that cannot be expelled from lungs under any conditions. Such measurements include the residual volume, functional residual volume, and total lung capacity [7] [8].

2.3 TESTS PERFORMED TO FIND THE RESPIRATORY PARAMETERS

Three different tests are performed using spirometer for finding the respiratory parameters :(i)Vital capacity test,(ii)Forced vital capacity test and (iii) Maximum voluntary ventilation test.

2.3.1 Vital Capacity test

The subject is asked to blow the air through the air through the flow sensor. A normal breathing should be performed for 3 or 4 times followed by a maximal inspiration and a maximal expiration. Thus the vital capacity test is measured by having the subject inspire maximally and then exhale completely into the flow sensor. The VC can also be measured from maximal expiration to maximal inspiration. Vital Capacity (VC), Expiratory Reserve Volume (ERV), Inspiratory Reserve Volume (IRV), Tidal Volume (TV) is the parameters that come under the Vital Capacity Test.

2.3.2 Forced Vital Capacity test

The forced vital capacity test is the most diagnostically significant test. The subject is asked to do normal breathing for one or two times followed by the largest possible inspiration [2]. When the subject cannot take in anymore air, then a maximal expiration should be done. All the inspiratory parameters i.e. peak inspiratory flow, peak expiratory flow, forced inspiratory vital capacity, forced expiratory vital capacity, etc. can be measured using the forced vital capacity test.

2.3.3 Maximum Voluntary Voluntary Ventilation Test

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The Maximum Voluntary Ventilation (MVV) test requires a large effort for adequate and reproducible results. The MVV is measured by having the patient breath as deeply and rapidly as possible for 12 seconds. The subject should be standing for this test. A breath rate of greater than 1.5 liters are guidelines. The test is conducted for 12 seconds. The actual values are extrapolated from 12 seconds to 1 minute and are expressed in liters per minute.

3. SPIROMETRY

Spirometry is the most basic and frequently performed test of pulmonary (lung) function. A device called a spirometer is used to measure how much air the lungs can hold and how well the respiratory system is able to move air into and out of the lungs. Because spirometry is based on a maximal forced exhalation, the accuracy of its results are highly dependent on the patient's understanding, cooperation, and best efforts [6][9].

Spirometry differs from peak flow readings in that spirometry records the entire forced breathing capacity against time, and peak flow records the largest breathing flow that can be sustained for 10 milliseconds. Both are often used in asthma care.

3.1 SPIROMETY TEST

This test is used to determine the cause of shortness of rule out any kind of obstructive disease that blocks breathing, or restrictive disease that limits the expansion and capacity of the lungs. Spirometry is most often used to diagnose and monitor lung problems, such as chronic bronchitis, emphysema, pulmonary fibrosis, chronic obstructive pulmonary disease (COPD), or asthma. Spirometry is also used to monitor how well medications for respiratory problems are working and to evaluate breathing capability prior to surgery.

3.2 NORMAL SPIROMETRY RESULTS

Normal spirometry results are based on the age, height, and gender of the person being tested and most are expressed as a percentage of a predicted value. Normal spirometry results include:

- Tidal volume – 5 to 7 milliliters per kilogram of body weight
- Expiratory reserve volume – 25 percent of vital capacity
- Inspiratory capacity – 75 percent of vital capacity
- Forced expiratory volume – 75 percent of vital capacity after one second, 94 percent after two seconds, and 97 percent after three seconds.

3.3 ABNORMAL SPIROMETRY RESULTS

Spirometry results are expressed as a percentage, and are considered abnormal if less than 80 percent of the normal predicted value. An abnormal result usually indicates the presence of some degree of obstructive lung disease such as asthma, emphysema or chronic bronchitis, or restrictive lung disease such as pulmonary fibrosis. FEV1 values (percentage of predicted) can be used to classify the obstruction that may occur with asthma and other obstructive lung diseases like emphysema or chronic bronchitis. Abnormal spirometry results include:

- FEV1 65 percent to 79 percent predicted = Mild obstruction
- FEV1 40 percent to 59 percent predicted = Moderate obstruction
- FEV1 less than 40 percent predicted = Severe obstruction

4. GENERAL DESCRIPTION OF NEURAL NETWORKS

Artificial Neural Networks have been motivated right from its inception by the recognition that the human brain computes in an entirely different way from the conventional digital computer. The brain is a highly complex, non-linear and parallel computer (information processing system). [4][5] It has the capability to organize its structural constituents, known as neurons, so as to perform certain computations (e.g., pattern recognition, perception, and motor control) as many times faster than the fastest digital computer in existence today.

Artificial neural networks employ a massive interconnection of simple computing cells referred to as "neurons" or "processing units". A neural network is a massively parallel-distributed processor made up of simple processing units, which has a natural property for storing experiential knowledge and making it available for use [13].In

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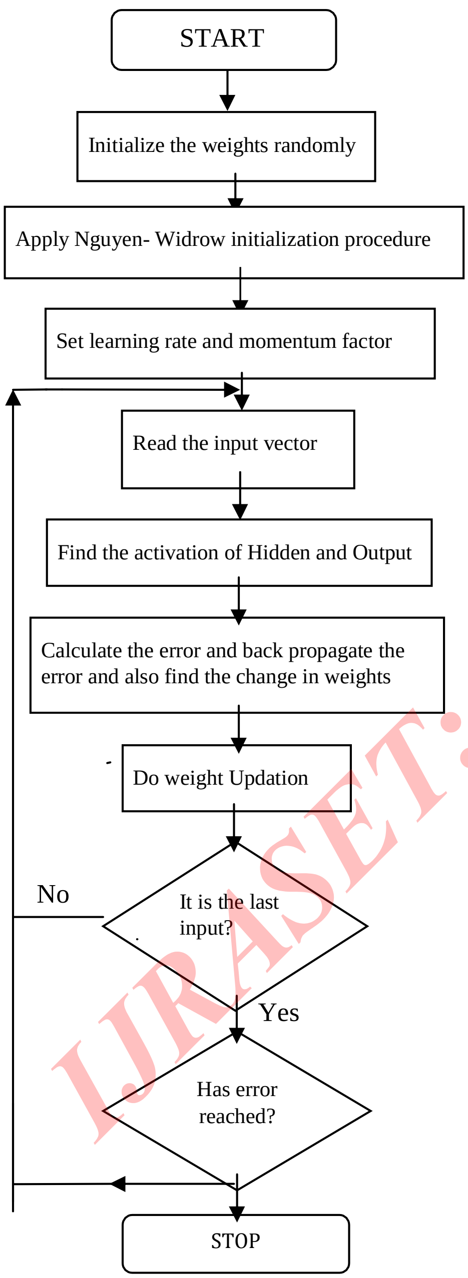
this work, Backpropagation Neural Network was used to classify the lung diseases.

FLOW CHART FOR BACKPROPAGATION NEURAL NETWORK



5. DATA REPRESENTATION SCHEMES

The Pulmonary Function Testing (PFT) database considered in this project has twenty-two attributes. There are eleven output classes. The original source of the sample database is from PSG Institute of Medical Science and Research, PSG Hospital. The input attributes of the patient considered to classify the diseases are Sex, Height, Weight, Age, Smoke Type, Subject Smoke,FEF 25(L/s),FEF 25-75,FEF 50(L/s), FEF 75(L/s), FET(s), FEV1(L), FEV1(L), FIV1%, FIVC(L), Post Drug, Reproducible, PEF (L/s),PIF (L/s),Best Trail Index. The output classes analyzed from the patients through Spirometry are Normal Spirometry, Restriction mild, and Restriction moderate, Restriction moderate Severe, Restriction Severe, Restriction Very Severe, Obstruction mild, Obstruction moderate, Obstruction Severe, Obstruction moderate Severe, and Obstruction Very Severe.

6. SYSTEM IMPLEMENTATION AND RESULTS

LabVIEW Software is used for implementation of the system. Analyses are based on Backpropagation Algorithm (BPN). LabVIEW Software is applied for analysis and diagnosis of the Respiratory disorders [11][12]. Sub VI's implemented in this project are:Input Vector Digitization, Target Vector Digitization, Random Weight Initialization, Computation of Hidden and Output unit Signal, Conversion of output to Decimal Value, Efficiency Calculation

There are two main VI's in this project. Performance Comparison is made between Backpopagation with momentum and Delta-bar-delta. The choice of initial weights will influence whether the net reaches global a global minimum of the error and, if so, how quickly it converges. The update of the weight between two units depends on both the derivative of the upper unit's activation and activation of the lower unit. For this reason, it is important to avoid choices of initial weights that would make it likely that either activations or derivatives of activations are zero. A common procedure is to initialize the weighs to random values between -0.5 and 0.5 (or between -1 and 1 or some other suitable interval). The values may be positive or negative because the final weights after training may be of either sign also. The Activation function is Bipolar Sigmoid to compute Hidden unit and Output unit Signals. The output value in bipolar form is converted to decimal value to diagnose the diseases and efficiency is calculated.

Table 1 The comparison between Backpropagation with momentum and Delta-Bar-Delta

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Backpropagation with momentum	Backpropagation with Delta-Bar-Delta
Number of Epochs = 1213	Number of Epochs = 707
Training Efficiency = 86 %	Training Efficiency = 86 %
Testing Efficiency = 90 %	Testing Efficiency = 95 %

CONCLUSION

In this project the LabVIEW based Lung Analyser is dealt. The work is mainly focused on the Analysis and Diagnosis of Lung Diseases depending upon the Lung parameter value obtained from spirometer. The methods described are simple and provides good performance under various lung parameter values. The analysis is based on pattern classification using Artificial Neural Network (ANN). The Backpropagation Algorithm is applied for classifying the lung diseases. Finally the diseases are classified into eleven classes according to the Lung parameters obtained from the patient's through spirometer. A virtual instrument for the diagnosis of the respiratory diseases is developed using the software package LabVIEW. The results obtained from the project suggest that the application of an ANN is feasible. Introduction of the ANN Algorithm drastically reduces complexity for classifying the diseases. Comparison is made between the Backpropagationwitht momentum and Delta-bar-Delta. The Number of iteration is reduced in case of Delta-bar-delta. The LabVIEW application for the Lung Analyser prolongs the life of the Lung Analysis leading to a minimum total cost. Hence when an intelligent technique like Neural Network is used, fast and smooth response is obtained. It is simple and easy to design such a System.

FUTURE SCOPE

Future scope, this project can be extended in real time by directly interfacing flow sensor and necessary hardware for estimating the lung parameters to LabVIEW Data Acquisition card for evaluation of lung parameters.

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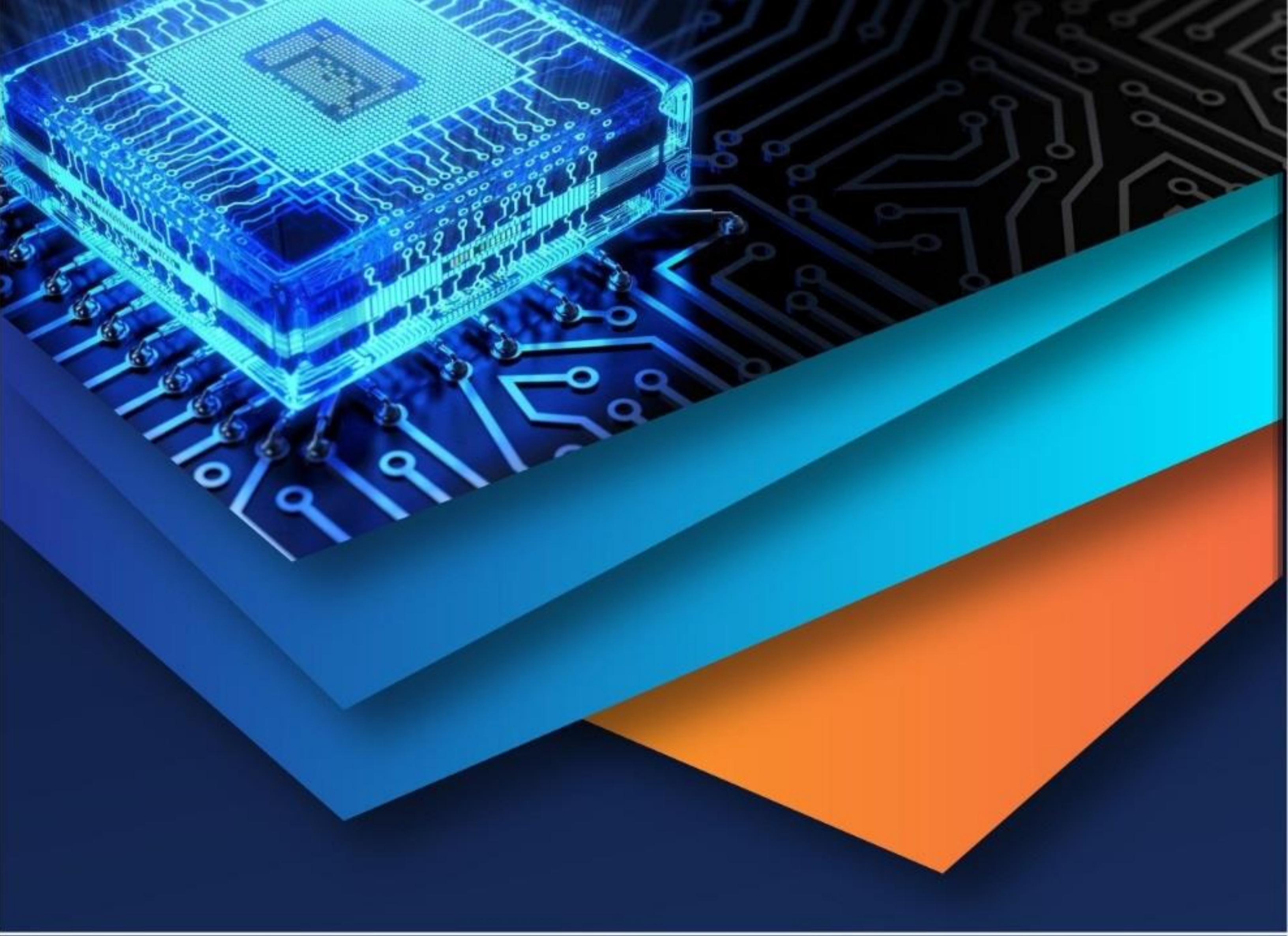

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