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Respiration in Forecasting Breathing Disorders

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***Abstract*— Physiological signals like ECG and respiratory signals play a vital part in predicting the patient's health status. Imprecise diagnosis of breathing patterns like tachypnea and bradypnea similar to cardiac arrhythmias will avoid erroneous treatment. In case when the respiratory signal cannot be acquired, it could be derived from ECG. This technique is called ECG derived respiration (EDR) technique and is useful in an ambulance and a home-based signal processing systems that help in Telemedicine. The processed signals are then classified with greater accuracy using a feed-forward neural network to be categorized into normal and abnormal signals. This helps in the precise diagnosis of multiple breathing disorders.**

***Keywords*— Electrocardiogram, EDR, Wavelet Transform**

I. INTRODUCTION

Respiration is a vital process in a human's physiological activity. It supports various physical activities within the body. With an increase in the rate of respiratory disorder cases globally, diagnosing the respiratory disorder with simple steps has become the need of an hour. With around billions of people globally and millions of people in India affected with respiratory disorders in 2019, diagnosing the respiratory disorder is very much necessary. Therefore, with common diagnosis done like electrocardiogram, the respiratory rate can be derived without any additional connections over the patient avoiding discomfort.

II. PHYSIOLOGICAL PARAMETERS

A. *Electrocardiogram*

Electrocardiography is the study of the electrical activity of the heart using Electrocardiograph. An output obtained from Electrocardiograph is called Electrocardiogram (ECG). The initial predictions from ECG start with heart rate calculation and the major diagnosis includes prediction of problems like global ischemia, culprit artery, etc.

B. *Respiration*

Breathing is essential for supplying oxygen to all parts of a living being to sustain life. The
respiratory tract is one of the most vulnerable parts of the human body in procuring infections.
There is an outspread of these infections compared to other communicable diseases since the mode of transmission is air utilized for an involuntary respiration process.

III RESPIRATORY DISORDERS AND HOW ECG IS USED TO DETECT BREATHING

It has been identified that respiratory tract infections are one of the major causes of death around the world. Each year it is estimated that 1.5 million people in developing countries die due to respiratory infections in which at least 42% have a lower respiratory infection and 24% have upper respiratory infections. Children are prone to these infections. Worldwide statistics show that hundreds of millions of people have been diagnosed with some form of respiratory disease and disorder.

Respiratory diseases are most commonly caused due to infections of microbes such as bacteria,viruses, and Fungus. Severe air pollution plays a major role in affecting lung health. In the case of prolonged exposure to toxic substances that can emit fumes of toxic gases affects the respiratory system leading to chronic diseases. People with low immunity have higher chances of acquiring respiratory diseases. Other causes include birth defects or underdeveloped lungs and climatic conditions may induce or fuel the disease.

The types of respiratory disease and disorders are generally classified into Chronic and infectious. Based on the regions affected, the diseases can further be categorized as 1) Airway disease 2) Air sac disease 3)Diseases in Interstitium 4)Diseases of Blood vessels 5)Disease affecting Pleura 6)Diseases of the Chest wall.

Airway diseases are diseases that occur in the Trachea and Bronchi. Conditions that occur in these parts of the respiratory system are COPD (chronic obstructive pulmonary disease), Chronic bronchitis, Acute bronchitis, Asthma, Emphysema, Cystic fibrosis. Diseases that affect Air sacs / Alveoli are Tuberculosis, Pulmonary edema, Pneumonia, ARDS (Acute respiratory distress syndrome), Lung cancer, Pneumoconiosis, Emphysema. Interstitial lung disease occurs at the Interstitium. Diseases such as Pneumonia and pulmonary edema can also occur at interstitium.

Blood clots and high blood pressure causes conditions like Pulmonary embolism and pulmonary hypertension causes shortness of breath leading to low blood oxygen levels and chest pain. Pleura is a thin lining over the

lungs and the inner walls of the chest. Diseases affecting these walls are Pneumothorax, Pleural effusion, Mesothelioma. Abnormalities in chest wall cause Neuromuscular disorders, Obesity hyperventilation syndrome.

Normally these respiratory disorders cause symptoms such as difficulty in breathing, breathlessness, stubborn cough, noisy breathing such as Course and fine Crackles, Polyphonic and Monophonic wheeze, stridor. Some non-respiratory conditions may also cause symptoms such as anemia and shortness of breath. To determine the cause of these symptoms and underlying conditions, there are numerous methods to detect any abnormality in the respiratory
tract.

Later these findings are then correlated with the existing symptom to precisely diagnose a respiratory disease or a disorder. During emergency situations, ambulatory services and in ICUs continuous monitoring of the
breathing rate and breathing patterns along with other physiological parameters are necessary for providing effective treatment to the patient. At these circumstances acquiring a physiological signal that can provide information about more than one parameter of interest will be helpful in reducing the number of pieces of equipment used, space utilized, and cost-effectiveness of the
facility. Thus a model that uses single-lead for the extraction of ECG derived respiration (EDR) signal was greatly appreciated lately. This facilitates continuous and simultaneous monitoring of the ECG and respiration signal of the patient. This was achieved by measuring the variations in ECG signals resulting from the change in position of the heart during Diaphragmatic breathing cycles and the change in heart rate during cyclic inhalation (increases) and exhalation (decreases) providing adequate information on the breathing pattern of the patient. ECG signals obtained from healthy subjects measure the respiration rate by determining these changes in the heart rate using variations in R-R intervals which will be synchronous with the respiration. Also in QRS waveforms, shortened R-R intervals are observed during inspiration, and extended R-R intervals are observed during expiration. EDR signals are extracted from these cyclic patterns created in
ECG and are processed for further analysis to determine the presence of abnormalities in breathing if any, due to possible underlying respiratory diseases.

or the slope range of the QRS complex, can be used to estimate the interaction between cardiorespiratory events.

IV ECG Derived Respiration

EDR is obtained from ECG. With proper filtering and processing of ECG, the EDR signal is derived.

C. Cubic spline interpolation

There are different kinds of interpolation, specifically, linear and spline. Linear interpolation will lead to straight up and down lines connecting the point of interest. Cubic spline interpolation is a procedure with which the specified points are connected with smooth curved appearance.

D. Filtering

Basic notch filters were implemented in filtering the acquired ECG signal from database.

E. Smoothening

The filtered signal was smoothed in order to avoid those noisy appearance caused after filtering the signal.

F. Wavelet Application

Wavelet is a kind of small part of a wave. This wavelet exits as various families. Daubechies wavelet family plays a major role in processing ECG signals. Especially Daubechies-6 wavelet plays an important role in filtering ECG signals along with specific wavelet coefficients.

V Cardiac Studies and their Influences on Respiratory Signals

Cardiorespiratory monitoring is an important biomarker for the diagnosis and management of multiple conditions related to interaction between heart and respiratory system. Despite the importance of monitoring respiration, its recording requires the use of invasive and intrusive sensors like thermistors, spirometers, and respiratory belts and commonly are associated with high cost and less comfort.
Also, this plays an important role for the development of ECG-based ambulatory systems, to determine the influences of technical and physiological factors on respiratory modulations [1].

The filling and emptying of the lungs cause changes in the electrical impedance of the chest. As a result, the morphology of the ECG is modulated by respiration. Carolina Varon et.al have stated that the respiratory rate, and even the respiratory wave morphology, can be approximated by ECG-derived respiration (EDR) [2] and they have explored various methods, which includes changes in the segment between the R-wave and the S-wave or the slope range of the QRS complex, can be used to estimate the interaction between cardiorespiratory events.

Sung-Bin Park et.al [3] have conducted a research on respiration signal extraction from electrocardiogram (ECG) using conductive textile electrodes and instantaneous frequency estimation implemented with Hilbert transform. Among 15 subjects, the most cases, all EDR and real respiration signals are almost identical in terms of respiration rate and also the intrathoracic impedance variation caused by respiration effort transfers to the skin electrode without loss. Their findings it is clear that it is a useful method for long-term home monitoring of sleep, and further makes it possible to measure respiration signals as well as ECG and heart rate variation using a Holter ECG machine and also will be useful to improve the home healthcare.

Charlton et. Al [4] proved from their results that ECG and Photoplethysmogram (PPG) have significant respiratory modulations including baseline wander (BW), amplitude modulation (AM), and frequency modulation (FM).

VI METHODOLOGY

The signals from Physionet Database named Fantasia was used. A total of 40 signals are there with 20 signals acquired from elderly subjects and 20 signals from young subjects. Also few simulated signals where used for testing purpose. The following procedure was followed in processing the signals downloaded from Fantasia Database in Physionet website:

1) The signal is filtered with notch filter.
2) Then the signal was smoothed.
3) The smoothed signal is processed with Daubechies 6 wavelet and corresponding wavelet coefficients.
4) Finally the previously obtained signal is smoothed.
5) This signal is then processed to find the R-peaks.
6) From the R-peaks, consecutive RR interval is calculated.
7) Later Heart rate for corresponding R-R intevals is calculated.
8) This is plotted using cubic spline interpolation and with proper filtering, EDR is obtained.
9) With a neat GUI, the respiration rate from EDR is calculated and then it is displayed as ormal or abnormal condition.

RESULT

The results obtained are displayed below.

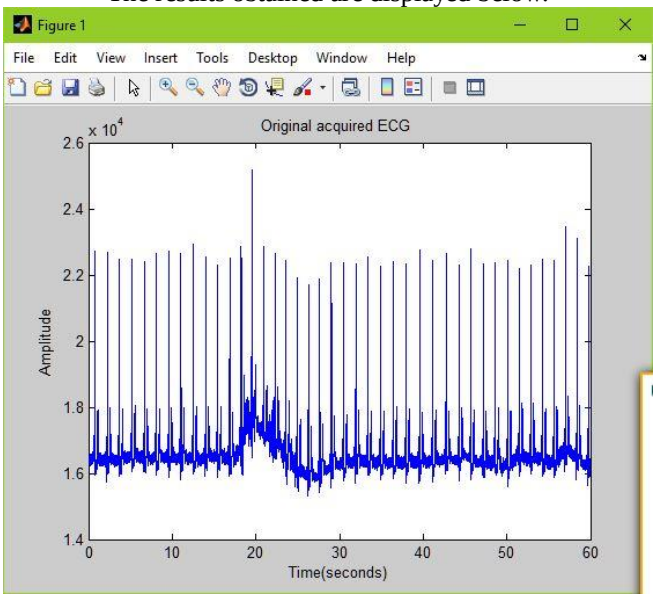

Fig: 1 Original acquired ECG for a subject

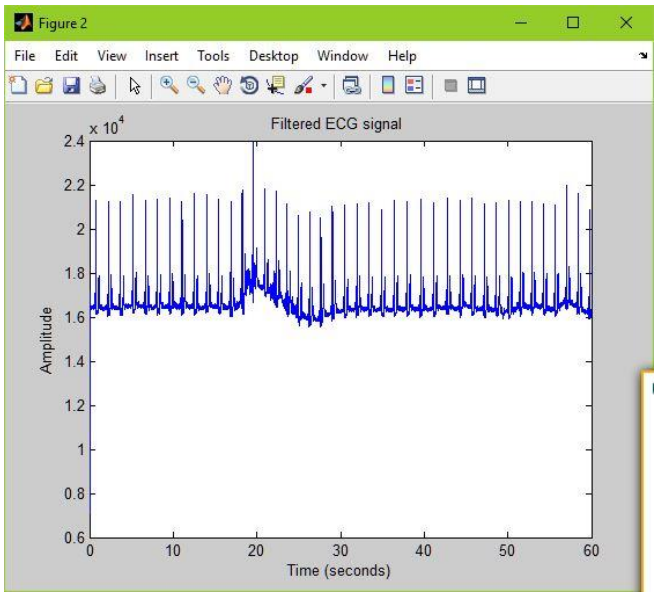

Fig:2 Filtered ECG signal for a subject

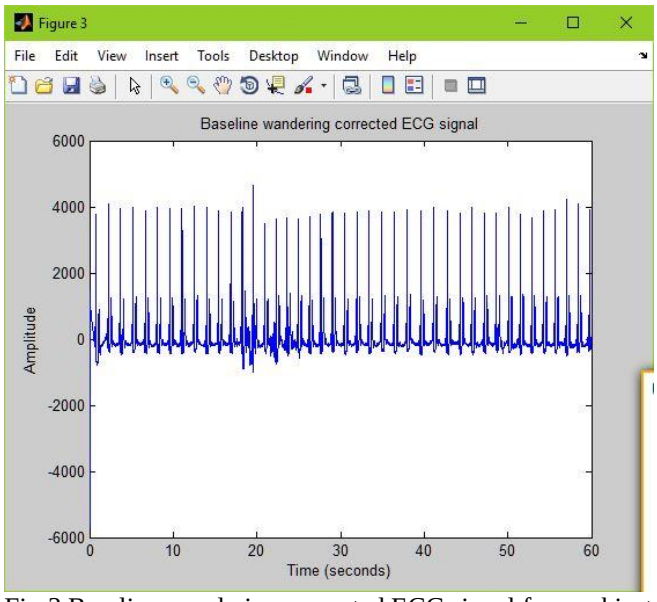

Fig:3 Baseline wandering corrected ECG signal for a subject

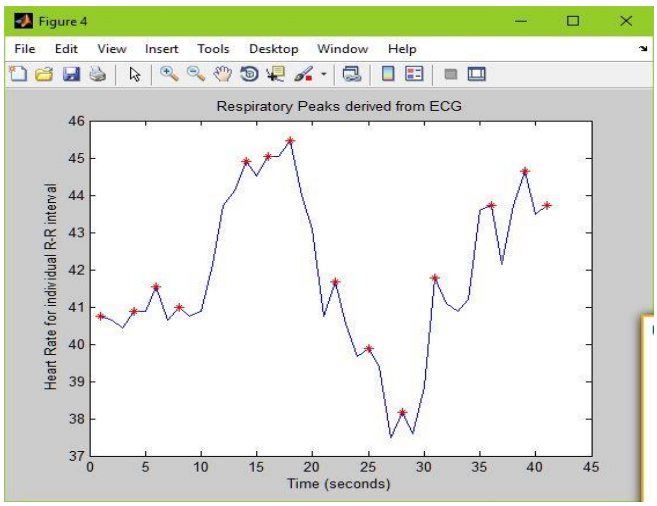

Fig:4 Respiratory peaks detected from ECG for a subject

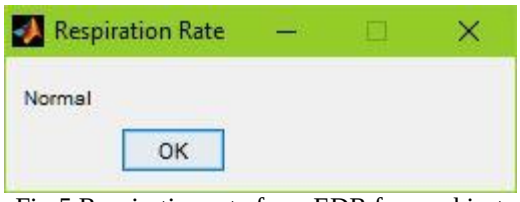

Fig:5 Respiration rate from EDR for a subject

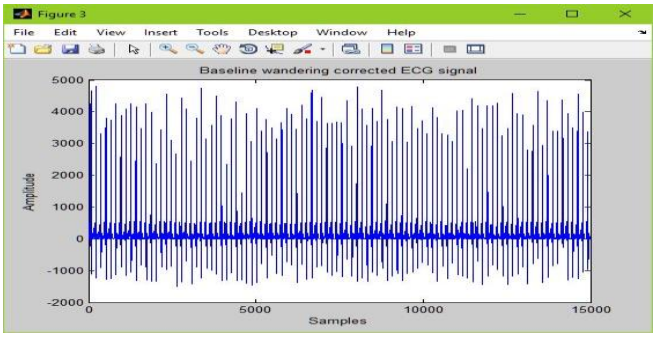

Fig:6 Baseline wandering corrected signal for a patient

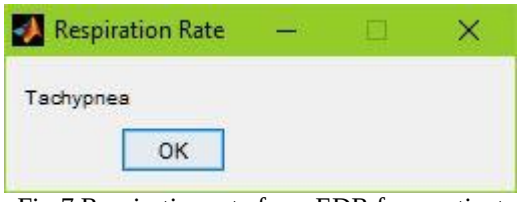

Fig:7 Respiration rate from EDR for a patient

CONCLUSION

Thus the signals were processed and the condition was predicted as normal or abnormal ones.

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