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SIMULATION AND ANALYSIS OF HYPERCALCEMIA, ATRIOVENTRICULAR BLOCK AND TACHYCARDIA OF ECG SIGNAL USING LABVIEW

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Abstract—This paper deals with the elicitation and distinguishing of the characteristics of different types of biomedical signals in the individual's PC with the help of NI LabVIEW software which interprets the obtained biomedical signal to know the state of the vascular system, which is one of the types of organ systems present in the human body. The data obtained from the biomedical signals will help to analyze the current situation of the patient or human body by comparing the parameters obtained from the diseased individual with the hale and healthy individual. By the breakdown of these parameters, the medical practitioner will be able to provide the proper medication to the patient and also will be able to undertake the obligatory precautions as necessary. Generally, the waveforms alone provide vague information i.e., they don't provide insight into the information regarding the disease and hence they need to be analyzed in an analytical method. Mathematical models are used to build the relationship between different biomedical signals and the organ systems in a computational way and then the parameters are then displayed on the display screen to give a comprehensive insight of the state of the system. The output of the ECG for cardiovascular diseases namely: Hypercalcemia, Atrioventricular Block, and Ventricular Tachycardia are acquired using LabVIEW.
Keywords—ECG Signal Analysis, Hypercalcemia, Atrioventricular Block, Tachycardia of ECG signal using LabVIEW,Cardiovascular diseases.

I.INTRODUCTION

Cardiovascular diseases (CVD's) have become the predominant cause of deaths globally. In olden days, patient's with Cardiovascular diseases were not given proper treatment due to the lack of medical support from the doctors as much sophisticated medical paraphernalia was not available to them. But now there have been tremendous advancements in the field of medical sciences. Many tools and mechanisms have been developed by the scientists which can diagnose and treat heart related diseases in the present world. Some of the tests that are used to diagnose cardio related diseases are Electrocardiogram (ECG), Holter monitoring, Echocardiogram, Stress test, Cardiac catheterization, Cardiac Computerized Tonography(CT) Scan, Cardiac Magnetic Resonance Imaging(MRI), The record or display of an individual's heartbeat produced by ECG is called Electrocardiogram. It is of the form of PQRST wave [1][2]. Any heart related diseases are detected or observed by the change in the adjacent intervals and amplitude of the waveform. The electrocardiogram and the parameters of a healthy individual are as shown below:The amplitude of P-wave is 0.25mV and R-wave is 1.60mV. Whereas the amplitude of Q-wave is 25% of R-wave and that of T-wave ranges between 0.1-0.5mV.The duration of the intervals are as shown below:The R-T interval ranges in between 0.12-0.20sec, Q-T interval ranges between 0.35-0.44sec, the S-T interval ranges between 0.05-0.155sec, P-wave interval being 0.11 sec and QRS interval being 0.09 sec.

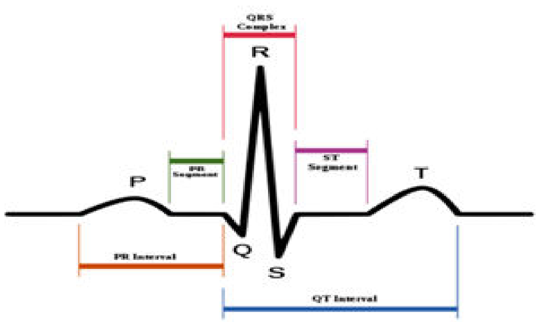

Fig 1. Electrocardiogram of a hale and healthy individual.

The electrocardiogram of a healthy individual is compared with that of an individual's infected with the cardiovascular disease. The set of tests that are required to be performed are conducted in order to diagnose and treat the disease. Like for example, many methods have been proposed to deal with ventricular arrhythmia based on auto correlation function, frequency domain features, time frequency analysis, wavelet transforms. The most efficient method that stood out among all of these is the real-time discrimination of ventricular tachyarrhythmia with Fourier transform neural network. In this method by observing QRS complexes in every heartbeat [10], VA are distinguished from normal heartbeats [3][4]. This method also achieved high specificity and sensitivity of greater than 0.98.

II. SIGNAL ACQUISITION THROUGH LABVIEW

LabVIEW has become a boon in the Biomedical Engineering field as the signal need to be pre-processed to determine a patient's situation by giving to the ECG can be generated by using the simulate ECG signal icon. Also, the different types of diseases can be selected by choosing the signal type through which we can visualize the signal generated by the heart when it is suffering from a particular disease i.e., the heart produces different types of waveforms for different kinds of diseases. For example, the signal generated by the heart patient suffering from Hypercalcemia is as shown in Fig 2 below:

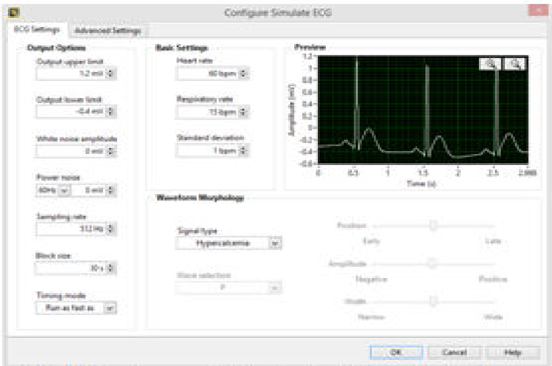

Fig.2. Signal generated by heart patient suffering from Hypercalcemia.

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ECG in LabVIEW takes the input signal only in .tdms format. So inorder to convert the data generated by the signal into .tdms format, we give the output of the simulate ECG signal to Write Biosignal ECG data [5] icon present in the biomedical toolkit as shown below:

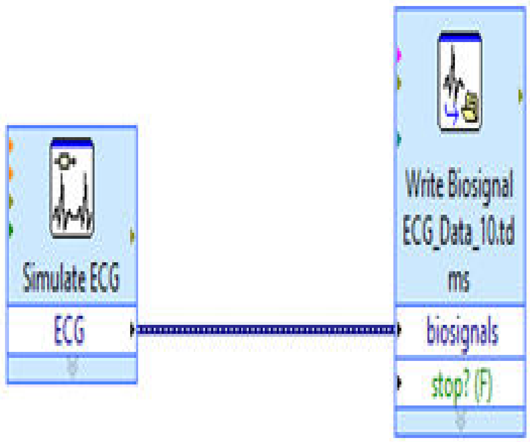

Fig.3. Conversion of signal data into .tdms format.

Also, remember that the file path has to be given in the Write Biosignal ECG data icon in the following method:C:\ProgramFiles(x86)\Nationalinstruments\LabVIEW2016\examples\Biomedical\Data\ECG_Data_10.tdms.

III. METHODOLOGY

The traditional way of acquiring a signal and processing it using ECG is shown in the block diagram below. During the signal processing due to the EMG and skin-electrode contact, some unavoidable noises arise causing distortion of the ECG spectrum [6][7] which helps in monitoring the electrical activity of the heart. In order to reduce or remove the noise from these sources, various methods had been stated such as time domain analysis but it failed to provide the complete analysis of the signal. Hence Fast Fourier Transform (FFT) came into limelight. But FFT technique failed to provide the exact location of the frequency components in the waveform. So among all the time and frequency transforms, Wavelet transform stood out and it's found to be more simple and beneficial. The theory of wavelet transform has originated from Signal Processing and has developed from the Fourier Transform. Wavelet transform of a signal is given as:

$$x_\omega(a,b) = \int_{-\alpha}^{\alpha} x(t)\Psi\left(\frac{t-b}{a}\right)dt$$

Wavelet transform of a function is defined as a linear combination of wavelet basis function. It performs the linear operation of the signal and the basis function (mother wavelet). A set of integral function is constructed by scaling and shifting the mother wavelet. The basis function is scaled by a factor 'a' and translated by a factor 'b' which results as shown below:

$$\Psi_{a,b}(t) = \frac{1}{\sqrt{a}}\Psi\left(\frac{t-b}{a}\right)$$

Using LabVIEW we follow a similar procedure but this method will reduce all the external error causing factors occurring during signal acquisition [5]. The traditional method uses different electrodes to be inserted into the human body which has several external factors affecting it like the ease of use, impedance mismatch problems. But as we are simulating the required signal, the specifications can also be adjusted as per the requirement to test the signal for further diagnosis. The block diagram of the features extraction is as shown below:

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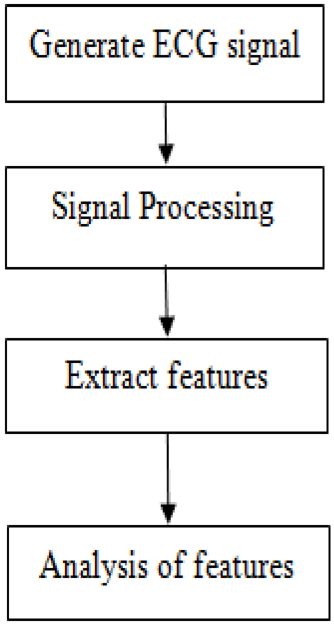

Fig 4. Block Diagram of the features extraction.

The block of code shown above contains the code placed in a while loop i.e., it implies the given set of ECG signals are executed continuously until the read bio signal icon throws an error or the number of iterations becomes zero. Initially, the signal from ECG is given to read icon which reads the signal which is stored in a file block by block. Then the signal is pre-processed by using band-pass filtering. The window used is Dolph-Chebyshev Window which minimizes the Chebyshev norm of the of the side lobes for a given main-lobe width 2Ꮚc. Then the signal is allowed to pass through extract ECG features icon which extracts all the parameters of the signal such as heart rate, a mean and standard deviation which is used for further analysis of the condition of the patient. Finally, these parameters are used to analyse and visualize the extraction results [8][9].

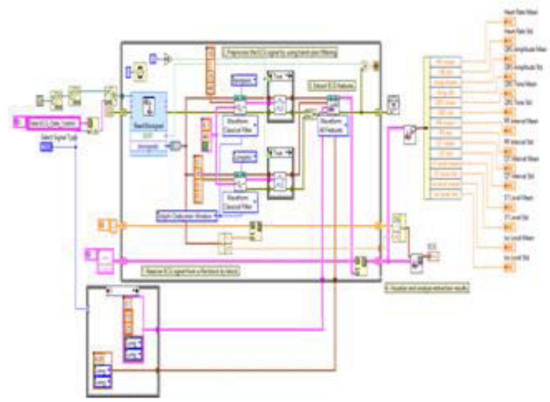

Fig.5. Graphical Representation of ECG using LabVIEW

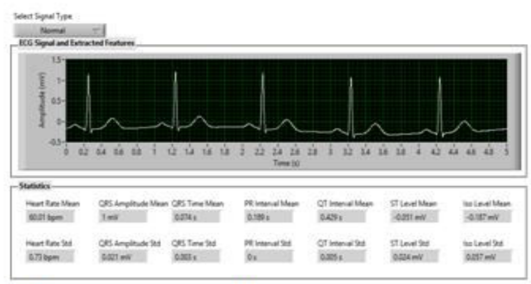

Fig 6. Display of parameters of ECG waveform during Normal condition.

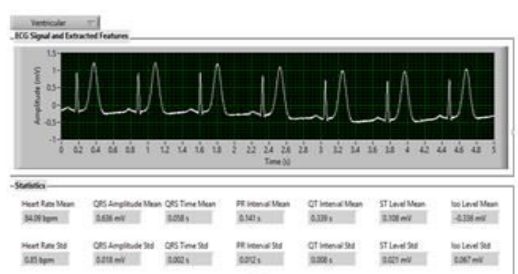

Fig 7. Display of ECG parameters for a patient diagnosed with Ventricular Tachycardia.

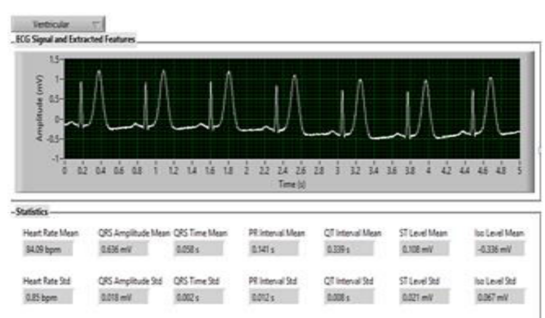

Fig 8. Display of ECG parameters for a patient diagnosed with Hypercalcemia.

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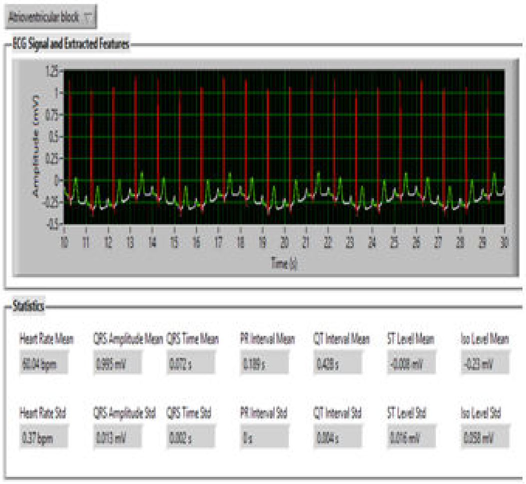

Fig 9. Display of ECG parameters for a patient diagnosed with Atrioventricular Block.

IV.RESULTS

Mean values and The standard deviation of various ECG features are discussed in table 1 and 2.The Fig.6 shows the inward eye on the ECG parameters for a healthy patient without any ailment. The Fig.7 depicts the ECG waveform of the cardiac patient effected with Tachycardia in which the heartbeat of a person exceeds the normal heart rate. The Fig.8 depicts the ECG waveform of the cardiac patient effected with Hypercalcemia in which there is a high level of Calcium in the blood serum. The Fig. 9 depicts the ECG waveform of the cardiac patient effected with an Atrioventricular block, which is a type of heart block in which the conduction between the atria and ventricles of the heart is impaired.Table 1 depicts the mean values of the various ECG features and Table 2, the standard deviations of them. We observe that the normal heart rate of a person is 60.01 bpm but in the diseased condition, there has been a huge variation of the functionality of the heart. Also in the case of Hypercalcemia, it causes an increase in heart rate and an inotropic effect which is a case of an increase in contractility. Ventricular Tachycardia also increases the heart rate due to the increase in the speed of beat of ventricles which is occurred due to the problem in electrical impulses generated by the heart or problem of the valvular heart disease. Even standard deviations have seen a huge deviation from the normal state functionality of heart

TABLE 1. MEAN VALUES OF VARIOUS ECG FEATURES

	Heart Rate (bpm)	Amplitude in mV			Interval in sec		
		QRS Complex	ST Segment	ISO	QRS Complex	PR Segment	QT Segment
Normal	60.01	1	-0.051	-0.187	0.074	0.189	0.429
Ventricular Tachycardia	84.09	0.636	0.108	-0.336	0.058	0.141	0.339
Hypercalcemia	59.9	1.022	0.041	-0.268	0.074	0.19	0.391
Atrioventricular Block	60.04	0.995	-0.008	-0.23	0.072	0.189	0.428

TABLE 2. STANDARD DEVIATION VALUES OF VARIOUS ECG FEATURES.

	Heart Rate (bpm)	Amplitude in mV			Interval in sec		
		QRS Complex	ST Segment	ISO	QRS Complex	PR Segment	QT Segment
Normal	0.73	0.021	0.024	0.057	0.003	0	0.005
Ventricular Tachycardia	0.85	0.018	0.021	0.067	0.002	0.012	0.008
Hypercalcemia	0.96	0.031	0.025	0.057	0.003	0.001	0.002
Atrioventricular Block	0.37	0.013	0.016	0.058	0.002	0	0.004

V.CONCLUSIONS

As per the reports of the catalogue, most of the deaths in the world are due to cardiac attacks. Many types of research have been done with the goal of minimizing these widespread diseases around the world. Diseases like Atrioventricular block and Tachycardia are serious issues regarding health and the conventional ECG monitoring of the patient is banal as the life of the patient is at risk. A sophisticated method of continuous monitoring of the patient's ECG signal is required. In this paper using the simulation of the ECG signal, various parameters of the ECG signal are enunciated for the clear and continuous diagnosis of the diseases like Hypercalcemia, Atrioventricular Block, and Ventricular Tachycardia which have been prevalent cardiac diseases in the current generation.

LabVIEW is a graphical programming tool which provides a user friendly workbench for creating VI's and verifying the outputs. Also, error detection becomes easy as they are highlighted which saves a lot of time in programming. By using different types of hardware like NI myDAQ and NI myRIO toolkits which are made available by the National Instruments alleviates the complexity of the method of diagnosis. The cost and storage of the data are greatly minimized which proves it is a utilitarian way of approach.

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