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Classification of Arrhythmia from ECG Signals using MATLAB

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ABSTRACT

An Electrocardiogram (ECG) is defined as a test that is performed on the heart to detect any abnormalities in the cardiac cycle. Automatic classification of ECG has evolved as an emerging tool in medical diagnosis for effective treatments. The work proposed in this paper has been implemented using MATLAB. In this paper, we have proposed an efficient method to classify the ECG into normal and abnormal as well as classify the various abnormalities. To brief it, after the collection and filtering the ECG signal, morphological and dynamic features from the signal were obtained which was followed by two step classification method based on the traits and characteristic evaluation. ECG signals in this work are collected from MIT-BIH, AHA, ESC, UCI databases. In addition to this, this paper also provides a comparative study of various methods proposed via different techniques. The proposed technique used helped us process, analyze and classify the ECG signals with an accuracy of 97% and with good convenience.

Keywords-- Electrocardiogram (ECG), Lead-II Configuration, Cardiac Arrhythmia, Signal Processing, Matlab

I. INTRODUCTION

ECG being a valuable technique invented by Willem Einthoven has been used for over a century for clinical applications and is the main tool used in clinical practice to record the electrical activities of the heart [27, 35].The ECG measurement is nowadays a part of the internal investigation carried out by doctors that is executed using a special device called the electrocardiograph, which consists of electrodes being placed on the surface of the body. The 12-lead ECG configuration is one of most commonly used, out of which, we in this paper are specifically dealing with the Lead-II ECG Configuration [1]. It is the most useful lead for detecting cardiac arrhythmias as it lies close to the cardiac axis (the overall direction of electrical movement) and allows the best view of P and R waves.

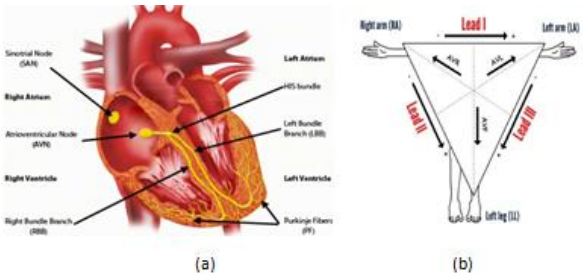

Fig 1: (a) A Cardiac Conduction System and (b) Lead-II ECG Configuration

Circulating and supplying blood and nutrients to the body is the primary function of the heart [14]. Hence, determination of the heart impulse results due to internal periodicity of the tissue under the combinational control of biochemical and neurological effects [54].The whole ECG signal recording is a combination of several consecutive cardiac cyclesthat results due to the depolarization and repolarization of the ions in the blood which include a fairy period of waves and peaks corresponding to the consecutive heart action phases [1, 49].

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The track of each heartbeat would consist of several waves/ peaks, segments, intervals and joints as shown in the figure below.

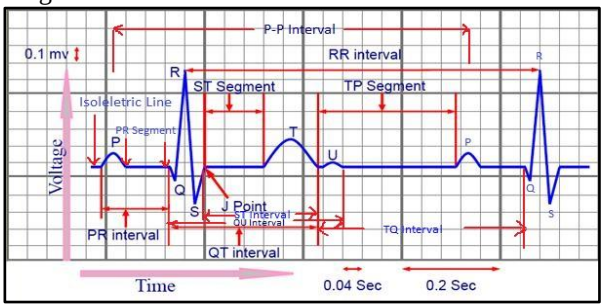

Fig 2: A General ECG Waveform

The table 1 shows the ECG features and descriptions.

Table1: ECG Features and their Description

FEATURE	DESCRIPTION
P WAVE	P-waves represent atrial depolarization.
Q WAVE	The normal Q wave represents septal depolarization and is any initial downward deflection after the P wave.
R WAVE	The R wave represents early ventricular depolarisation and is normally the easiest waveform to identify on the ECG.
S WAVE	The first negative deflection after the R wave represents the S wave indicating the late ventricular depolarization.
T WAVE	The T-wave represents ventricular repolarization.
U WAVE	U waves represent re-polarization of the Purkinje fibers that indicates the last remnants of the ventricular repolarization. Generally it is 0.05mV and has duration of 0.1s.
P-R SEGMENT OR PQ SEGMENT	The PR or PQ segment is the flat, usually isoelectric segment between the end of the P wave and the start of the QRS complex. This segment represents the time the impulse takes to reach the ventricles from the sinus node.
P-R INTERVAL OR PQ INTERVAL	The time taken for electrical activity to move between the atria and ventricles is represented by this interval.
R-R INTERVAL	The RR-interval begins at the peak of one R wave and ends at the peak of the next R wave and represents the time between two QRS complexes.
P-P INTERVAL	It indicates the duration of atrial cycle (atrial rate).
QRS COMPLEX	The depolarization of the ventricles is represented by the QRS Complex.
QT INTERVAL	It represents the time taken for the ventricles to depolarize and then repolarize.
ST SEGMENT	The isoelectric line that represents the time between depolarization and repolarization of the ventricles (i.e. contraction) represents the ST segment.
J-POINT	The J point is the junction between the termination of the QRS complex and the beginning of the ST segment.
T-P INTERVAL	The isoelectric interval on the electrocardiogram (ECG) is TP segment that represents the time when the heart muscle cells are electrically silent.
T-Q INTERVAL	Termed as the diastolic interval through the ECG.
Q-U INTERVAL	The QU interval is a measure of the time between the start of the Q wave and the end of the U wave in the heart's electrical cycle.

ECG signal processing if done in the time domain would mean using values between the beat intervals and amplitudes. And the respective location, durations and amplitude of these peaks carry very crucial information about the functioning of the heart [2]. The processing is done to free the ECG from noise and artifacts. Nowadays, ECG has become a golden medium for detecting Arrhythmia and Cardiovascular diseases and could detect bifid P wave in lead II (P Mitrale).

II. CARDIAC ARRHYTHMIA IN THE ECG SIGNAL

We all know that heart diseases constitute and are recognized as one of the major causes of death in the world and the best diagnostic tool to determine any abnormality in the cardiac function or tissue damage would be through ECG. ECG varies from person to person due to the anatomy of the heart, the difference in position, age, size, relatively body weight, chest configuration and several various other factors [15, 61].

In the morphology of ECG signal where the normal rhythm of the heart represents no disease or disorder is called Normal sinus rhythm (NSR). Cardiac Arrhythmia could be defined as a disorder or disturbance or any abnormality resulting in the normal activation sequence of the myocardium giving rise to irregular heartbeat or abnormal rhythm of the heart that may cause

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permanent injury to the heart. Although cardiac arrhythmia is one of the leading causes of death, it can be treated if detected on time [16, 22, 66,].Arrhythmia can take place in a healthy heart having minimal consequence, but may also indicate a serious problem that leads to stroke or sudden cardiac death, scarring of heart tissue or change of heart structure or heart blocks or premature beats due to lack of blood flow to the body[32].

III. CARDIAC ARRHYTHMIA CLASSIFICATION

Arrhythmia could be of many types and can be classified with respect to three factors:

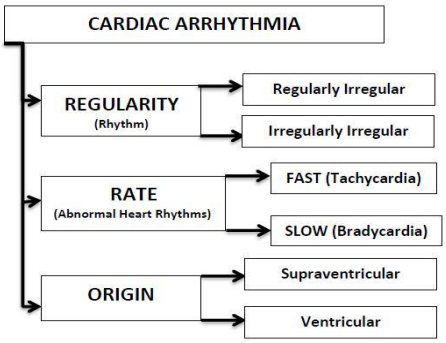

Fig 3: Classification of Cardiac Arrhythmia

1. REGULARITY

It is a step of analyzing an ECG rhythm.

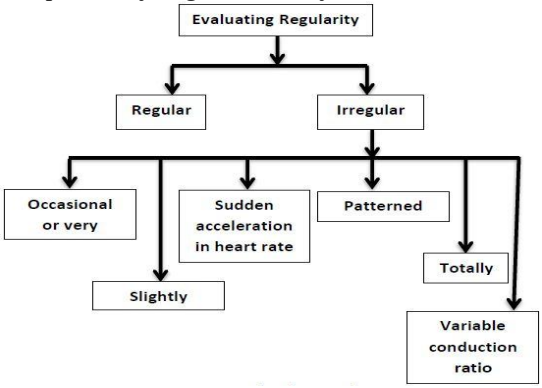

Fig 4: Classifying Regularity

- A rhythm would be termed as Regularly, Irregular, if it has some form or regularity to the pattern of the irregular complex.
- An Irregularly, Irregular rhythm could be defined as a rhythm that has no pattern at all and whose all intervals are haphazard and do not repeat with an occasional accidental exception.

2. RATE

The heart rate of NSR is generally defined by 60 to 100 beats per minute in a normal resting person.

- If a resting heart beats at a rate of 100 or more beats per minute in an average adult, this would represent abnormal rapid beating of the heart defined as Tachycardia resulting in a drop of pumping efficiency, adversely affecting perfusion.
- Bradycardia is defined as a resting heart rate below 60 beats per minute and can adversely affect vital organs.

3. ORIGIN

Basically it tells us from where the impulse has been originated from in the heart.

a) Supraventricular Arrhythmias

Supraventricular arrhythmias are the ones that start in the atria or atrioventricular (AV) node (a group of cells located between the atria and the ventricles). Several types to be mentioned would be atrial fibrillation (AF), atrial flutter, paroxysmal supraventricular tachycardia (PSVT), Wolff-Parkinson-White (WPW) syndrome and AVNRT [32].

b) Ventricular Arrhythmias

These arrhythmias start in the heart's lower chambers, the ventricles and can be very dangerous and usually require medical care right away. They include ventricular tachycardia and ventricular fibrillation (v-fib)and PVC [32].

IV. THE LITERATURE SURVEY

In a research article put forth by Yan Sun et al, Characteristic wave detection in ECG signal was done using the multiscale morphological derivative (MMD) transform-based singularity detector which was used for the detection of fiducial points in ECG signal. The developed MMD method exhibited good potentials for automated ECG signal analysis and cardiovascular arrhythmia recognition [5].

Thakor et al proposed a paper on Noise Cancellation and Arrhythmia Detection by using several adaptive filter structures to eliminate the diverse forms of noise. The adaptive filter minimizes the mean-squared error between a primary input, which is the noisy ECG, and a reference input, which is either noise that is correlated in some way with the noise in the primary input or a signal that is correlated only with ECG in the primary input. Since arrhythmia detection is a complex problem, data adaptive algorithm was considered to be desirable [6].

Classification of Cardiac Arrhythmia by Thorat et al proposed a real time feature extraction and classification method using genetic programming wherein they have extracted the nonlinear parameters by analyzing Heart Rate Variability (HRV) signals and the various features including time domain and frequency domain. This programming is then applied to classify heart Arrhythmias using both HRV and ECG features. The Genetic programming selects effective features, and then finds most suitable trees to distinguish between different types

of the Arrhythmia with an average accuracy of 99.33% [13, 16].

In the approach paper of Preeti Raman et al, it was seen that Classification of Heart Diseases based on ECG analysis was done using data mining techniques. The number of extracted features was reduced utilizing PCA (Principal Component Analysis) and clustered utilizing FCM (Fuzzy C_Means) algorithm followed by using SVM (Support Vector Machine) for classification purpose with an accuracy of 90% [22].

In Automatic Classification of ECG Signal for Heart Disease Diagnosis proposed by Vijayavanan stated that in order to classify ECG signals into normal and arrhythmia affected (abnormal) category, morphological features need to be extracted. In their case, they have used Probabilistic neural network (PNN) which is the modeling technique engaged to capture the distribution of the feature vectors for classification. This technique could accurately classify and discriminate the difference between normal ECG signal and arrhythmia affected signal with 96.5% accuracy [26].

In the paper Detection of Cardiac Arrhythmia from ECG Signals, Arumugam et al presented a survey of various approaches used in the feature extraction and classification of ECG signals. Their research states that many methods like wavelet transform, Independent Component analysis (ICA), Permanent Component analysis (PCA), Time Domain, Wavelet Transform, Power Spectral Density and Fuzzy logic with Neural network techniques have been used either separately or in combination for extracting features from ECG signal. It is found from this survey that wavelet transform is used for feature extraction and SVM classifier is used for classification of bio signals as it gives high classification accuracy [27].

In a review paper by Anand Kumar Joshi, it was seen that ECG feature extraction was developed and evaluated based on the multi-resolution wavelet transform followed by analysis of ECG normal & abnormal wave forms [32].

S.T.Sanamdikar et al described a literature review paper wherein Arrhythmia Analysis and interpretation of ECG signal were done using modified Wavelet transform tech, Daubechies six coefficient wavelet, Pan-Tompkins algorithm, hidden markov models, Fuzzy logic methods, neural network, support vector machine, genetic algorithm, PCA and SVM methods. It was seen that the other methods gave an accuracy of 98% but by using wavelet transform, an accuracy of 100% was achieved [49].

In a research paper proposed by V. Rathikarani et al, it was seen that to exemplify ECG signals, features such as Linear Predictive coefficients (LPC), Linear predictive cepstral coefficients (LPCC) and Mel-Frequency Cepstral Co-efficient (MFCC) are extracted. This is then followed by using SVM which is the model engaged tocapture the distribution of the feature vectors for classification and calculating the performance. The proposed method can accurately classify and discriminate the difference between normal ECG signal and arrhythmia affected signal with 94% accuracy [51].

P. G. Patel et al proposed an efficient method for ECG Signal Analysis by first removing noise and then detecting QRS peaks by using Pan Tompkins algorithm which was then followed by calculation of heart rate and detecting various arrhythmicabnormalities using Matlab [52].

A paper presented by Bekir Karlik et al proposed an approach of classifying arrhythmia by using Artificial Neural Networks. As a result of 5000 serious iteration, 95% identification was achieved [54].

Literature survey carried out by Nanditha et al proposed an innovative technique and algorithmic approach for extraction of signal parametric measures, denoising and classifying final ECG signal for detecting Arrhythmias using Undecimated Wavelet Transform [56].

In a paper proposed by Afseen Naaz et al, it was found out that morphological features give good results in arrhythmia classification while statistical feature were useful because of variation in ECG signal for different patients using wavelet transform [62].

In a review paper presented by Simranjeet Kaur stated a study of the ECG signal, peaks and of the various techniques that are used for the detection of disease. It is also seen that to increase the accuracy of the peak detection for the disease detection with less error and to evaluate the performance of the ECG signal analysis further work need to be done using some other technique [67].

In a survey carried out by I.S.Siva Rao et al, it was seen that Cardiac Arrhythmias were detected using Computational Intelligence techniques [68].

In a paper for detection and classifying ECG abnormalities proposed by Mahalakshmi Ponnusamy et al, it was seen that heart abnormalities were diagnosed accurately using multi model methods. The data acquisition was achieved from the relevant database, then preprocessing the data was done using Base Line Correction (BLC), inflection point detection using Power line interference, Feature Extraction by using GLCM method and finally features were classified and abnormalities were detected using the SVM classifier [72].

A survey carried out by S.Celin et al, a proposal of different methods of feature extraction and classifying both normal and abnormal ECG signals were discussed [80].

A paper proposed by Chusak Thanawattano et al, it was proposed that cardiac arrhythmia features would be extracted by applying the autoregressive signal modeling. The different coefficients of the 4th to 9th-order AR models were tested with the support vector machine in order to investigate the arrhythmia which had an accuracy of 97.11% [81].

In a paper proposed by Mrs. B.Anuradha et al for cardiac arrhythmia classification, four non-linear parameters were considered for cardiac arrhythmia classification of the ECG signals which were Spectral entropy, Poincaré plot geometry, Largest Lyapunov exponent and Detrended fluctuation analysis which was extracted from heart rate signals. Linguistic variables (fuzzy sets) were used to describe ECG features, and fuzzy conditional statements to represent the reasoning knowledge and rules. This method had an overall accuracy of 93.13% [82].

Thara Soman et al proposed a paper where machine learning schemes, OneR, J48 and Naïve Bayes were used to classify arrhythmia from ECG medical data sets [83].

In a paper proposed by Indu Saini et al, a neural network technique with error back propagation method were used to classify four different types of arrhythmias, namely, Left bundle branch block (LBBB), Right bundle branch block (RBBB), Atrial premature beat (APB) and Paced Beat (PB) with normal ECG signal. The multilayer perceptron feed forward neural network had been used for modeling the network architecture [84].

Hadji Salah et al proposed a system that is based mainly on Wavelet Transform to extract features and Kohonen self organization map the arrhythmias and detects them [85].

In a paper proposed by B. Anuradha et al, the same above techniques of nonlinear parameters were considered as used in [110] which were then followed by using ANN classifier used for the arrhythmia classification which had an accuracy of 90.56% [86].

F. Yaghouby et al presented a paper wherein an effective arrhythmia classification was done using an algorithm related to the heart rate variability (HRV) signal. The proposed method was based on the Generalized Discriminant Analysis (GDA) feature reduction technique and the Multilayer Perceptron(MLP) neural network classifier [87].

This paper presented by R. Ganesh Kumar et al tells us that an ECG classification method for arrhythmic beat classification was done using RR interval. The methodology is based on discrete cosine transform (DCT) conversion of RR interval [88].

Classification of Arrhythmia presented by Saleha Samad et al used machine learning algorithm in order to classify arrhythmia wherein the classifiers used are Nearest Neighbors, Naive Bayes', and Decision Tree classifier which gave an average accuracy of 53% [89].

Mi Hye Song et al proposed an algorithm for arrhythmia classification associated with the reduction of feature dimensions by linear discriminant analysis (LDA) and a support vector machine (SVM) based classifier for classification with an average accuracy of 99.35% [90].

WAVELET BASED ECG ARRHYTHMIA CLASSIFICATION presented by RaoRane Shweta et al proposed a work for classifying cardiac arrhythmia diseases using the. Support Vector Machine (SVM) and Genetic Algorithm approaches (GA-SVM method). A genetic algorithm was used for ECG arrhythmia classification and it was used to improve the generalization performance of the SVM classifier [91].

N P. Joshi et al proposed a new approach for heartbeat classification using Wavelet transform and independent component analysis (ICA) which was later used for classifying the abnormalities [92].

V. THE PROPOSED SYSTEM

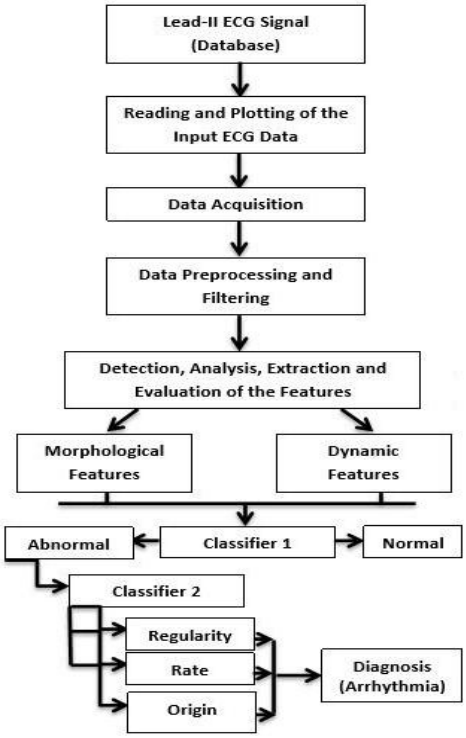

Fig5: The Proposed Approach

VI. METHODOLOGY OF PROPOSED SYSTEM

Step 1: Database Collection

Initially ECG signals were collected from variety of databases like the MIT-BIH (The Massachusetts Institute of Technology– Beth Israel Hospital Arrhythmia Database), AHA (The American Heart Association ECG Database), ESC (The European Society of Cardiology ST-T Database) and UCI (Machine Learning Repository). The database consisted of several different ECG format waveforms like .mat, .csv, .xml, .dat or .txt. The collections of databases were done from the database banks, ECG Simulators, ECG Machines along with an ECG Amplifier in practical laboratories and Electrocardiographsfrom the hospitals.

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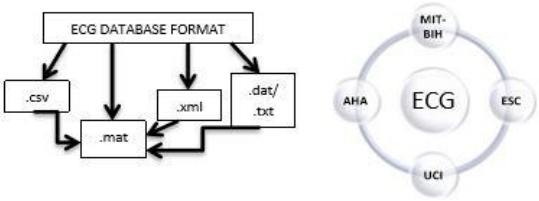


Fig 6: Databases and Formats

Step 2*: *Reading and Plotting of ECG Signal

In order to process an ECG signal, we first need to read and plot the signal. Our Project has been implemented using the multipurpose tool i.e. the MATLAB Environment. If the signal is raw, which usually is unless it's taken from a filtered database, we need to perform initialization and remove the base and gain by using the following formula:

$$Yi = \frac{Yi - Base}{Gain} \qquad (1)$$

Where Yi= ECG Sample
Base= Baseline Value
Gain= Gain Factor

Once done, we can proceed to reading and plotting of the signal on Matlab. Depending upon the various formats, some signals could be plotted directly (.mat) and some required conversion from one format to the required format ((.csv, .xml, .dat or .txt) to .mat) by choosing the appropriate frequency and threshold along with re-dimensioning of the variable matrix.

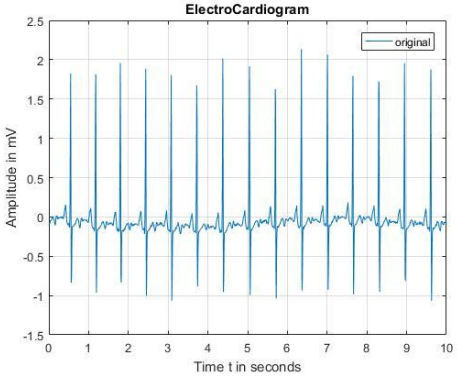
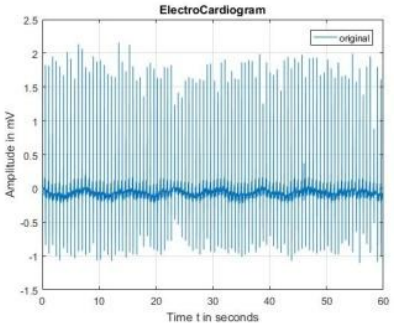
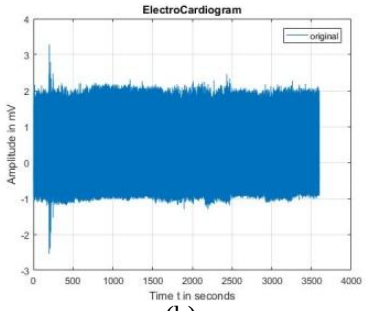


Fig 7: An Original ECG Signal (10 sec) (Normal)



(a)



(b)

Fig 8: ECG Signals (a) 60 sec and (b) 3600 sec (Normal)

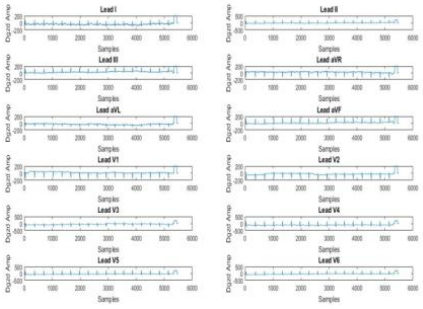


Fig 9: Plotting of 12 Lead Configuration ECG Signal from the .xml format to .mat signal

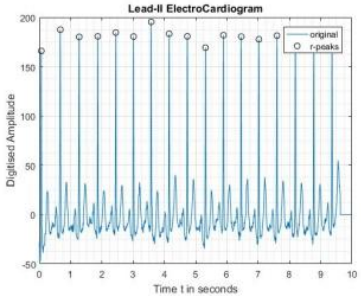


Fig 10: A Lead-II ECG Configuration extracted from 12 Lead Configuration ECG signal

Step 3:Preprocessing of the ECG Data

In the preprocessing stage, the noise is removed or suppressed using specific filters in order to extract the required information from the signal and for noise reduction.

This could be done either by performing Amplitude Normalization where in each sample of signal is divided from max of absolute value of signal in order to limit signal dynamic range from -1 to 1, i.e.

$$Variable = \frac{xi}{max(|x|)} \qquad (2)$$

Where xi= ECG Sample at a point
x= ECG Sample
or by filtering the signal.

The .mat format signal could be directly plotted in Matlab using a specific command. Considering the .csv and .dat format signals, Conversion and Zero Phase

Filtering were done in order to plot it. In case of the .xml format signal, the same procedure was carried out in order to plot the signal which represented all the 12 Lead Configurations followed by extracting the required signal configuration needed to work on (Lead-II).

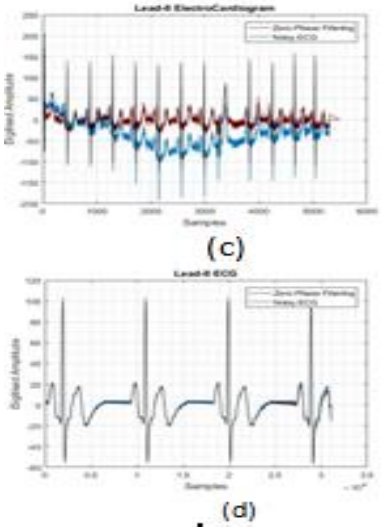


Fig 11: Zero Phase Filtering of Extracted Lead-II ECG Signal to (.mat) from (c) (.xml) and (d) (.csv)

Step 4:Feature Extraction and Evaluation

The feature extraction stage is used to extract diagnostic information from the ECG signal.

Feature extraction and evaluation can be either done to find out:

- Morphological Features
- Dynamic Features

Morphological Features would mean to determine the size, shape and structure of the ECG signal including the fiducial points like the peak points, segments and interval durations.

Dynamic features would mean extracting RR interval features, Heart rate, HRV and the R/P ratio.

An ECG Signal is the combination of various Peaks, Waves, Valleys, Segments, Intervals, Complexes and Points.

In order to classify an ECG signal as Normal or Abnormal, the very first step would be to identify these attributes and store the values in specific variables and then classify the various abnormalities.

i. Since R is considered to have the largest amplitude and is the sharpest component with respect to all the other peaks in a Normal Lead-II ECG Signal, detection of R peaks were done by obtaining the local minima larger than an adaptively set threshold using which the amplitudes, the temporal locations and durations were estimated.

ii. This was then followed by calculating the R-R Interval using the R-Spike Detection Method which is basically calculating the interval between one R-Spike and the next R-Spike (successive R's).

iii. This was then used to calculate the heart rate which could be defined as how fast the person's heart could beat in a minute.

Depending upon the individual, body size, age, heart conditions, whether the person is sitting or moving, medication use and even air or temperature, the heart rate could vary.

Number of Heart Beats per minute= Heart Rate (BPM)

Initially the mean value of the R-R Interval is calculated and then this duration is then divided into 60. The resulting equation would be:

$$\boldsymbol{Rate = \frac{60}{R\text{–}R\ Interval\ (Avg)}} \quad \textbf{(3)}$$

iv. The physiological phenomenon of variation in the time interval between heartbeats is termed as Heart rate variability (HRV). This is calculated by

$$\boldsymbol{HRV = (HRVmax - HRVmin) * 100} \quad \textbf{(4)}$$

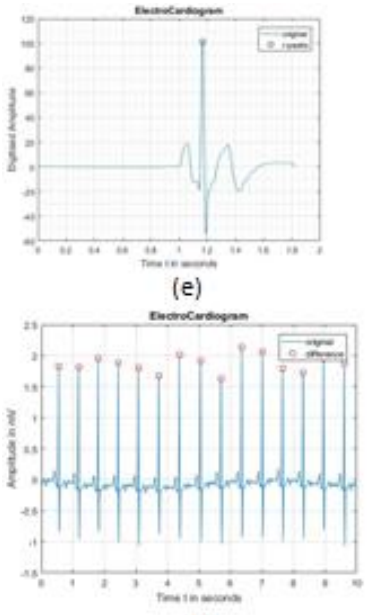


Fig 12: Detection of R Peaks and the fiducial features (e) and (f)

v. Detection of QRS Complex was done using the Pan Tompkins Algorithm where in the ECG was first filtered using a band pass filter followed by differentiating the signal in order to get the slope information. This was then followed by squaring the signal which made the entire signal values positive, concluding it with moving window integration which was done to obtain the waveform feature information. After moving window integration, thresholding of the obtained signal was done. If a peak exceeded the threshold

during the first step of analysis, it was classified as a QRS peak (Complex). This was then followed by calculating the Area under the QRS Complex to calculate the work done by the heart (not mandatory).

The estimated area under the QRS Complex is found to be 4.24 mVps.

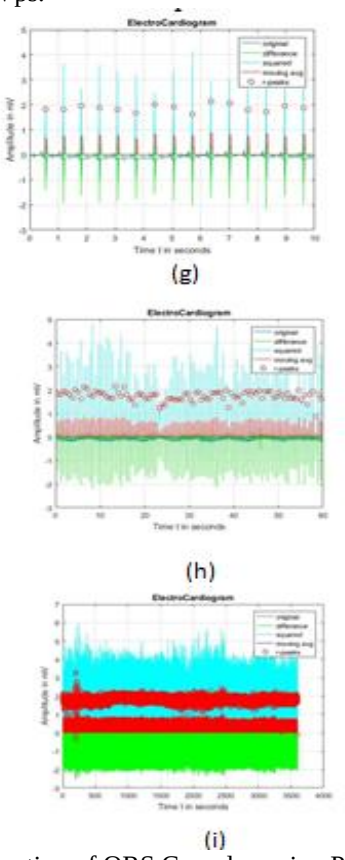


Fig 13: Detection of QRS Complex using Pan Tompkins Algorithm and the area under the QRS Complex for (10s, 60s, 3600s) (g, h, i resp.)

vi. The next step was to detect the Q and S peak by finding out the first local minimum from the left of the positive R wave and the first local minimum from the right of the positive R wave respectively along with its amplitude, locations and durations followed by finding out the Duration of the QRS Complex.

vii. Using the Moving Window Integration technique along with the Threshold Detection method, we could detect the P and the T peak points in the ECG signal along with their amplitude, locations and durations of the P and T waves as well.

viii. The R to P ratio was computed by using

$$\frac{R}{P} = \frac{R\ Peak\ (Amplitude)}{P\ Peak\ (Amplitude)} \qquad (5)$$

ix. Since the waveform boundaries are detected, the onset and offset of every wave is known. This feature could be used to calculate the various segments and intervals that make up the ECG. The segments calculated were PR or PQ Segment and ST Segment. The intervals calculated were PR or PQ Interval, QRS interval and TP Interval.

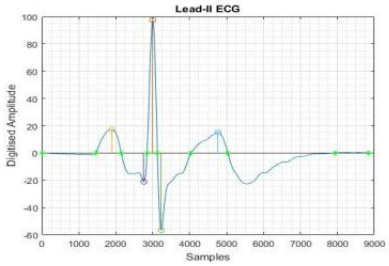


Fig 14: Detection of Peak Points and Locations; P, Q, R, S, T Waves

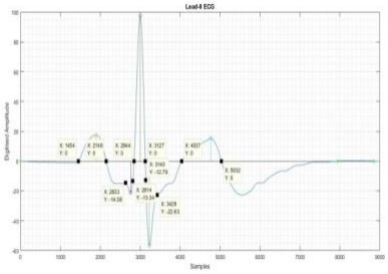


Fig 15: Detection of Various Segments and Intervals

VII. ANALYSIS AND RESULTS

- The very first classification involved would be to classify an ECG normal or abnormal.
- The second classification would classify the various types of arrhythmia or abnormalities found in the ECG signal.

The table displayed below gives the value of the average of more than 80 samples taken and analyzed in Matlab and that could be considered as Normal ECG based on the characteristics observed.

Table 2: ECG Signal Features and their Respective Values (Normal)

FEATURES	**VALUES**	
General Factors	**Values**	
Heart Rate	60-100 bpm*	
R-R Interval	0.6*s to 1.2*s	
Heart Rate Variability	+/-10%* to +/-30%*	
R to P Ratio	3* to 12*	
Waves	**Amplitude(mV)**	**Duration(s)**
P Wave	0.1*-0.35*	0.07*-0.12*
Q Wave	0.1*-0.3*	<0.04*
R Wave	0.8*-1.5*	0.035*-0.09*
S Wave	0.5*-0.9*	0.03*-0.05*
T Wave	0.15*-0.6*	0.1*-0.250*

Segments/Intervals	Duration(s)
PQ or PR Segment	0.04*-0.12*
PQ or PR Interval	0.1*-0.2*
QRS Complex	0.06*-0.12*
ST Segment	0.07*-0.12*
QT Interval	0.320*-0.450*
TP Segment	<0.420*

- ***These obtained values in the table are calculated manually as well as using specific algorithms through computer processing in Matlab by analyzing more than 80 samples and is verified by doing a lot of literature review and is approved by the doctors.**
- **The entered values in the table above are the average values of more than 80 samples after processing.**

Any value or feature that does not fall into the criteria and has a haphazard shape that does not have regularity and rhythm as defined in table 2 would be considered as an abnormal ECG. Accordingly, the following waveforms could be classified as abnormal as they do not satisfy the following criteria mentioned in table 2.

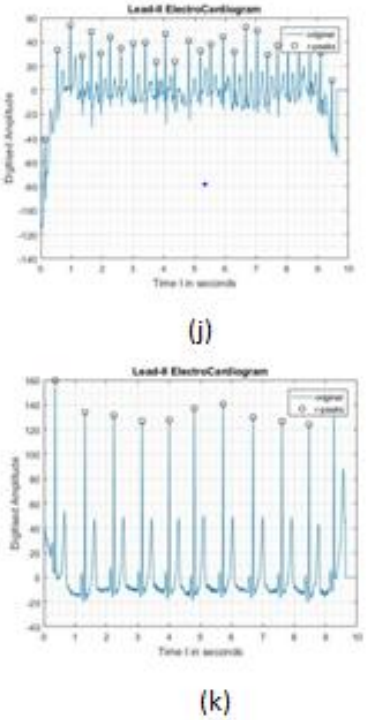


Fig 16: Abnormal ECG Waveforms (j, k)

The second classification is based on classifying the abnormal ECG waveform into the specific arrhythmic category. This was done as below.

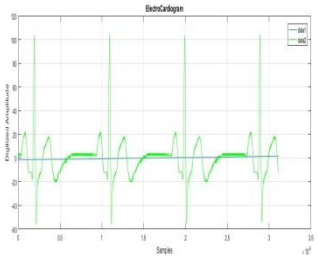


Fig 17: Plotted Waveform of the Arrhythmia Signal (Bradycardia)

The ECG Analysis after processing 10 signals of similar kind states that it has a Regular Rhythm and all values of the Waves, Segments and Intervals fall within the normal range but the rate observed in such signals fall below 60 BPM. The Rate observed in Fig. 17is below 60 BPM that is 47 BPM at rest, which is not within the normal range. This represents **BRADYCARDIA**.

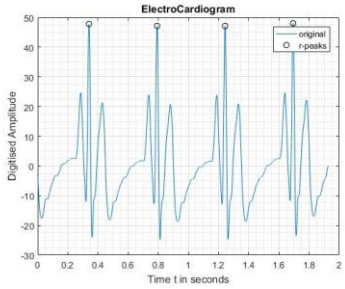


Fig 18: Plotted Waveform of the Arrhythmia Signal (Tachycardia)

The ECG Analysis after processing 10 signals of similar kind states that it has a Regular Rhythm and all values of the Waves, Segments and Intervals fall within the normal range but the rate observed in such signals lie above 60 BPM. The Rate observed in Fig. 18 is above 60 BPM that is 133 BPM at rest, which is not within the normal range. This represents **TACHYCARDIA**.

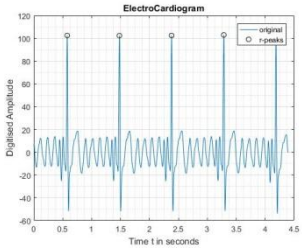


Fig 19: Plotted Waveform of the Arrhythmia Signal

The ECG Analysis after processing 10 signals of similar kind states that it does not have a Regular Rhythm and few of the Waves, Segments and Intervals are either absent or immeasurable. The Rate observed in Fig. 19 is 67 BPM at rest. This represents an **ABNORMAL ECG Signal**. Since few features are indiscernible along with a Chaotic Rhythm and the QRS Complex duration is 0.0842 s, from the literature review, it can be concluded that this

could represent **ATRIAL FIBRILLATION.** This represents an **ABNORMAL ECG Signal**.

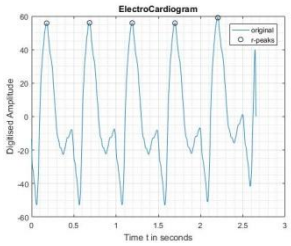


Fig 20: Plotted Waveform of the Arrhythmia Signal

The ECG Analysis after processing 10 signals of similar kind states that it does not have a Regular Rhythm and few of the Waves, Segments and Intervals are either absent or immeasurable. The Rate observed in Fig. 20 is 118 BPM at rest. This represents an **ABNORMAL ECG Signal**. Since few features are indiscernible and the QRS Complex duration is 0.5296 s, which is wide and bizarre and from the literature review, it can be concluded that this could represent **VENTRICULAR TACHYCARDIA**. This represents an **ABNORMAL ECG Signal**.

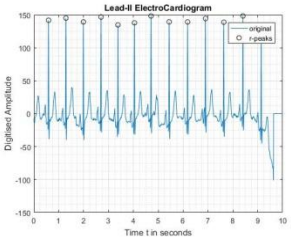


Fig 21: Plotted Waveform of the Arrhythmia Signal

The ECG Analysis after processing 10 signals of similar kind states that it does have a Regular Rhythm and the Waves, Segments and Intervals are measurable. The Rate observed in Fig. 21 is 84 BPM at rest. It has a bifurcated P Wave, it can be concluded that this could represent **P MITRALE**. This represents an **ABNORMAL ECG Signal**.

VIII. CONCLUSION

Biomedical signals are non-stationary signals whose analyses require better time and frequency resolution. Such analysis include de-noising, filtering, normalizing, squaring, averaging, encoding, decoding, compressing, decompressing, de-interleaving, constructing, reconstructing and comparing of the data.In consultation with the cardiologists and after a lot of processing and analyzing, it was seen that Lead-II ECG Configuration can detect Arrhythmias, P Mitrale and P Pulmonale.

The results obtained from our project cannot be immediately applied to the population. Many of our subjects sobered from a combination of heart defects. Classification and Detection of the heart defects using Lead-II configuration requires many more samples. Future research heading in this direction is necessary with a larger sample size in order to accurately pinpoint the various heart defects individually.

IX. FUTURE SCOPE

ECG is a form of biomedical waveform that provides a lot of necessary information to the physicians. The research work carried out has the ability to work in real time as well as of line environment for detection of arrhythmias. Any further research heading in this direction needs a large sample of data in order to accurately classify and detect the heart defects using Lead-II configuration individually. As the microprocessor and its parent semiconductor technology continue to evolve, the resulting devices will stimulate development of many new types of medical instruments.

Work is needed to be done on the hardware for successful implementation of the method devised. Moreover the work can be further improved by developing disease diagnostic clinical applications with the assistance of encoding, decoding, compression and decompression schemes for ECG.

Research can be extended on developing the logic to detect and analyze more number of arrhythmias or diseases which can be detected using Lead-II configuration. It can be made more compact with latest technology.

The detailed parameters of such signals can be studied for the purpose of training or generating a robust ECG classifier. With a larger database of heart defects at different stages will make the analysis more full proof. To come up with still simpler methods for ECG signal Analysis, a lot of research needs to be done on the properties. Modification of enhancement can be done using more evolved techniques. Hence our future work will be dedicated to an improved feature classification and maybe location.

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