A Literature Review on Arrhythmia Analysis of ECG Signal

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Abstract: *Arrhythmia analysis of ECG signal plays a significant role in diagnosing most of the cardiac diseases. One cardiac cycle in an ECG signal consists of the P-QRS-T waves. This proposed paper discusses various techniques and transformations proposed earlier in Literature for extracting feature from an Arrhythmia Analysis and interpretation of ECG signal. In addition this paper also provides a comparative study of various methods propose.*

Keywords: *Arrhythmia, ECG, Tachycardia, Bradycardia and QRS detection etc.*

1. INTRODUCTION:

1.1 Electrocardiogram:

Electrocardiogram (ECG) is a diagnosis tool that reported the electrical activity of heart recorded by skin electrode. The morphology and heart rate reflects the cardiac health of human heart beat . It is a non invasive technique that means this signal is measured on the surface of human body, which is used in identification of the heart diseases. Any disorder of heart rate or rhythm, or change in the morphological pattern, is an indication of cardiac arrhythmia, which could be detected by analysis of the recorded ECG waveform. The amplitude and duration of the P-QRS-T wave contains useful information about the nature of disease afflicting the heart. The electrical wave is due to depolarization and re polarization of Na+ and k-ions in the blood.
The ECG signal provides the following information of a human heart,
1] Heart position and its relative chamber size
2] Impulse origin and propagation
3] Heart rhythm and conduction disturbances
4] Extent and location of myocardial ischemia
5] Changes in electrolyte concentrations
6] Drug effects on the heart.
ECG does not afford data on cardiac contraction or pumping function.

1.2 Arrhythmias in ECG signal

The normal rhythm of the heart where there is no disease or disorder in the morphology of ECG signal is called Normal sinus rhythm (NSR). The heart rate of NSR is generally characterized by 60 to 100 beats per minute. The regularity of the R-R interval varies slightly with the breathing cycle. When the heart rate increases above 100 beats per minute, the rhythm is known as sinus tachycardia. This is not an arrhythmia but a normal response of the heart which demand for higher blood circulation .If the heart rate is too slow then this is known as bradycardia and this can adversely affect vital organs. When the heart rate is too fast, the ventricles are not completely filled before contraction for which pumping efficiency drops, adversely affecting perfusion.

1.2.1 Sinus Node Arrhythmias

This type of arrhythmia arises from the S-A node of heart. As the electrical impulse is generated from the normal pacemaker, the characteristic feature of these arrhythmias is that P wave morphology of the ECG is normal. These arrhythmias are the following types: Sinus arrhythmia, Sinus bradycardia, and Sinus arrest etc.

1.2.2 Atrial Arrhythmias

Atrial arrhythmias originate outside the S-A node but within the atria in the form of electrical impulses. These arrhythmias types are given bellow,
Premature Atrial Contractions (PAC)
This arrhythmias results an abnormal P-wave morphology followed by a normal QRS complex and a T-wave. This happens because of an ectopic pacemaker firing before the S-Anode. PACs may occur as a couplet where two PACs are generated

consecutively. When three or more consecutive PACs occur, the rhythm is considered to be atrial tachycardia. Atrial Tachycardia. The heart rate atrial tachycardia is fast and ranges from 160 to 240 beats per minute in atrial tachycardia. Frequently atrial tachycardia is accompanied by feelings of palpitations, nervousness, or anxiety.

Atrial Flutter

In atrial flutter, the atrial rate is very fast, ranging from 240 to 360 per minute. The abnormal P-waves occur regularly and so quickly that they take morphology of saw-tooth waveform which is called flutter (F) waves.

Atrial Fibrillation

The atrial rate exceeds 350 beats per minute in this type of arrhythmias. This arrhythmia occurs because of uncoordinated activation and contraction of different parts of the atria. The higher atria rate and uncoordinated contraction leads to ineffective pumping of blood into the ventricles. Atrial fibrillation may be intermittent, occurring in paroxysms (short bursts) or chronic

1.2.3 Junctional Arrhythmias

Junctional arrhythmias are originated within the A-V junction in the form of the impulse comprising the A-V node and it's Bundle. The abnormal in P wave morphology occurs because of this arrhythmias .The polarity of the abnormal P-wave would be opposite to that of the normal sinus P-wave since depolarization is propagated in the opposite direction – from the A-V node towards the atria.

Premature Junctional Contractions (PJC)

It is a ventricular contraction initiated by an ectopic pacemaker in the atrio -ventricular (AV)node. In premature junctional escape contraction, a normal-looking QRS complex prematurely appears, but without a preceding P-wave, but the morphology of T-wave is normal

1.2.4 Ventricular arrhythmias

In this type of arrhythmias, the impulses originate from the ventricles and move outwards to the rest of the heart. In Ventricular arrhythmias, the QRS-complex is wide and bizarre in shape.

Premature Ventricular Contractions (PVC)

In PVC the abnormality is originated from ventricles. PVCs usually do not depolarize the atria or the S-A node and hence the morphology of P-waves maintain their underlying rhythm and occur at the expected time. PVCs may occur anywhere in the heart beat cycle. PVCs are described as isolated if they occur singly, and as couplets if two consecutive PVCs occur.

Ventricular Tachycardia (VT)

The heart rate of ventricular tachycardia is 110 to 250 beats per minute. In VT the QRS complex is abnormally wide, out of the ordinary in shape, and of a different direction from the normal QRS complex. VT is considered life-threatening as the rapid rate may prevent effective ventricular filling and result in a drop in cardiac output.

Ventricular Fibrillation

Ventricular fibrillation occurs when numerous ectopic pacemakers in the ventricles cause
different parts of the myocardium to contract at different times in a non-synchronized fashion.

Ventricular flutter exhibits a very rapid ventricular rate with a saw-tooth like ECG waveform.

1.2.5 Atrioventricular Blocks

It is the normal propagation of the electrical impulse along the conduction pathways tothe ventricles, but the block may delay or completely prevent propagation of the impulse to the
rest of the conduction system.

A first-degree AV block is occurred when all the P-waves are conducted to the ventricles, but the PR-interval is prolonged. Second-degree AV blocks are occurred when some of the P waves fail to conduct to the ventricles. In third-degree AV block, the rhythm of the P-waves is completely dissociated from the rhythm of the QRS-complexes. Each beat at their own rate

1.2.6 Bundle Branch blocks

Bundle branch block, cease in the conduction of the impulse from the AV-node to the whole conduction system. Due to this block there may occur myocardial infarction or cardiac surgery .The bundle branch block beat is categories into two types. These are Left bundle branch block beat (LBBB) and Right bundle branch block beat (RBBB). In LBBB the left bundle branch will prevent the electrical impulses from the A-V node from depolarizing the left ventricular myocardium in the normal way. When the right bundle branch is blocked, the electrical impulse from the AV node is not able propagate to the conduction network to depolarize the right ventricular myocardium.

2. Problem definition:

Presently, many Cardiologists face difficulty in making a correct diagnosis for ECG arrhythmia diseases. In addition to this also conventional technique of visual analysis is more complicated and requires experienced and time. The information obtained from an Electrocardiogram can be used to discover different types of heart diseases. It may be useful for seeing now well the patient is responding to treatment therefore a computerized interpretation of ECG and problems will build for analyze the different arrhythmias using wavelet transform. As mentioned in literature analysis of ECG arrhythmias accuracy are about 90 to 98% that's why by using wavelet transform method we are trying to obtained100% accuracy in arrhythmia analysis.

3. Motivation

1] The state of cardiac heart is generally reflected in the shape of ECG waveform and heart rate.ECG, if properly analyzed, can provide information regarding various arrhythmia diseases related to heart.
2] Clinical observation of ECG can take long hours and can be very tedious. Moreover, visual analysis cannot be relied upon and the possibility of the analyst missing the vital information is high. Hence, computer based analysis and classification of Arrhythmia diseases can be very helpful in diagnosis.
3] Various contributions have been made in literature regarding detection and classification of ECG Arrhythmias. Most of them use either time or frequency domain representation of the ECG waveforms, on the basis of which many specific features are defined, allowing the recognition between the beats belonging to different classes.
4] The most difficult problem faced by today's automatic ECG arrhythmia analysis is the large variation in the morphologies of ECG waveforms. Thus our basic objective is to come up with a simple method having less computational time without compromising with the accuracy.
5] This objective has motivated me to search and experiment with various techniques.

4. Literature Survey:

J.I.Willams et.al.[1] has carried out the measurement analyzed independently by a group of cardiologists &AHA. Analysis of set of recommendations aimed at standardizing measurement in quantitative ECG is presented. These AHA recommendations have led to the world wide recognition. BekirKarhket et al.[2] carried out artificial Neural network of ECG signal analyzed in the time domain thus corresponding arrhythmias are determined by using ANN, around 95%result is achieved for identification of arrhythmia. Chuang-chienet et.al.[3] has done efficient arrhythmia detection algorithm using correlation coefficient in ECG signal for QRS complex are detected, the correlation coefficient and RR interval were utilized to calculate the similarity of arrhythmia. S. C. Saxena et.al.[4] has done combined modified Wavelet transform tech for Quadratic spline wavelet is used for QRS detection and Daubechies six coefficient wavelet used P and T detection and diagnosis of cardiac disease. Stefan Gradl et.al. [5] had carried out analysis of A)Pan-Tompkins algorithm for QRS-detection (B) template formation and adaptation; (C) feature extraction; (D) beat classification. The algorithm was validated using the MIT-BIH Arrhythmia and MIT-BIH Supraventricular Arrhythmia databases. More than 98% of all QRS complexes were detected correctly by the algorithm. Overall sensitivity for abnormal beat detection was 89.5% with a specificity of 80.6%.J. Lee, K. et.al.[6] has carried out input feature By wavelet transform and linear discriminate analysis. This proposed algorithm he obtain good accuracy of arrhythmia detection that of NSR,SVR,PVC and VF was 98.52, 98.43,98.59 and 98.88% respectively. Pedro R.Gomes,et.al[7] carried out the wavelet transform and hidden markov models. Experimental results are obtained in real data from MIT-BIH arrhythmia data base show that outperforms the conventional standard linear segmentation. V.Rathikaraniet.et. al.[8] has carried out the linear predictive coefficients, Linear predictive cepstral coefficients and melfrequency cepstral coefficients This method can accurately classify and discriminate the difference between normal ECG signal and arrhythmia affected signal with 94% accuracy.Sarkalehet.et. al.[9] has done the discrete wavelet transform and neural networks with DWT
is used for processing ECG recording and extracting some arrhythmia and neural n/w perform classification task. This method is 96.5 accuracy. Narendra Kohliet et.al. [10] has studied the SVM methods four algorithms One against One (OAO), one against All (OAA), Fuzzy Decision Function (FDF) and Decision Directed Acyclic Graph (DDAG) principal component analysis(PCA) method. Results are obtained from SVM methods, four well-known and widely used algorithms performing Classification of ECG datasets through SVM based methods, One Against All (OAA) gives better results than classification without feature selection. Rune Fensli, EinarGunnarsonet.et.al.[11] has analyzed the wireless and wearable sensor ECG system, hand held device with RF receiver and arrhythmia algorithm. The concept for wireless and wearable ECG sensor transmitting signal to a diagnostic station at the hospital and detecting rarely occurrences of cardiac arrhythmia..Khaled Daqrouqand et.al.[12] studied the continuous wavelet transform CWT for analyzing ECG signals and extracting desired parameters like arrhythmia .this method gives clear threshold between Nomocardia ,Bradycardia and tachycardia. S.Karpagachelvi, et.al.[13] studied the Fuzzy logic methods, neural network, support vector machine ,genetic algorithm and WT ECG feature

extraction plays a significant role in diagnosing most of the cardiac disease. It determines the amplitudes and intervals in the ECG signal for subsequent analysis. V.Vijaya,k.kishanrao et.al.[14] has studied the Pan Tomkins algorithm(it is implemented for the detection QRS complex on normal and arrhythmia database and discrete WT.Cardiac arrhythmia is the most common causes of death.ECG feature extraction has developed and evaluated an algorithm for R Peak and QRS complex detection using WT has been development.

P. G. Patel,et.al. [15] studied the Pen Tompkins Algorithm(efficient method for ECG Signal Analysis which is simple and has good accuracy and less computation time. For analysis the ECG signals from MIT database are used. The peak detection is very important in diagnosis arrhythmia which is proved as tachycardia, bradycardia, asystole, second degree AV block. The results show that from detected QRS peaks, arrhythmias which are based on increase or decrease in the number of QRS peak, absence of QRS peak can be diagnosed .A.R.Saheb et.al.[16] has analyzed the design a heart diagnosis instrument that has very low complicated computations. Designed classifier gives accuracy 98% have obtained for three different arrhythmia include RBBB,LBBB and normal heart rhythm are analysed. A Dliou ,alatifet.al.[17] has analyzed the three time frequency tech –choi-willams distribution, Bessel distribution and born Jordan distribution are applied for analyzing supraventricualr ECG signal comparative performance study of three time frequency techniques are applied for analyzing supraventricualr ECG signal results that the choi-willams technique gives good performance as compared to other time –frequency tech.

A fahoumet.al.[18] has analysed the work dealing with classification problem of four different arrhythmias :NSR –normal sinus rhythm,AF-atrial fibrillation, ventricular fibrillation(VT)and ventricular tachycardia(VT),RPS. Nonlinear dynamical behaviour of the ECG arrhythmia which used to identify the cardiac arrhythmias. This algorithm shows that sensitivity and specificity are within range of 87.7 -100%.the classification accuracy is 100%for VF arrhythmia . .V Mahesh et.al.[19] has studied the discrete wavelet transform, heart rate variability and logistic model tree. These LMT classifier to classify 11 different arrhythmia and results obtained 98% accuracy. Szi-Wen Chen et.al.[20] has modified sequential probability ratio test Using this technique they decreases the overall rate error rate 5% of previous result. M.R. Mhetre1et.al.[21] has analysed the Pan Tompkins algorithm has been modified and used. This software can be immensely helpful to the medical fraternity. An attempt is tried to provide a treatment plan for the more risky and frequently occurring arrhythmias. Heike Leutheuseret.al.[22] has analyzed the feature extraction from pan-tompkins algorithm and Hierarchical system. Early detection of arrhythmic beats in the ECG signal could improve the identification of patients at risk from sudden death for coronary heart disease.

4.1 Concluding Remarks-

In literature review it is found that the detection and classification of ECG arrhythmia has carried out but accuracy of detection of ECG arrhythmia is about 90 to 98%. From by using wavelet transform method we are trying ECG arrhythmias can be analyzed for 100% accuracy, that gives the detection and classification results better to improve the heart diseases of human being.

5. Contributions and Results:

1. ECG data base
2. Pre-processing of ECG signal
3. QRS detection, R peak detection
4. Feature extraction of complete ECG
5. Arrhythmia classifications
6. Disease diagnosis

5.1ECG data base

5.1.1 MIT-BIH Arrhythmias database

The MIT/BIH arrhythmia database is used in the study for performance evaluation. The database contains 48 records, each containing two-channel ECG signals for 30 min duration selected from 24-hr recordings of 47 individuals.

5.1.2: Common Standard for Quantitative Electrocardiography (CSE):

The European community in the year 1980, started a project under the leadership of late J. I.Willems with an aim of establishing "common standards for Quantitative Electrocardiography (CSE)".the working party developed for the three CSE reference databases.

5.1.3 AAMI Standard

MIT-BIH heartbeat types are combined according to Association for the Advancement of Medical Instrumentation (AAMI) recommendation. AAMI standard emphasize the problem of classifying ventricular ectopic beats (VEBs) from the non- ventricular ectopic beats.

5.2 Pre-processing

The main objective of this processing is to identify the P,Q,R,S&T waves and to locate characteristics points P_{on}, ,P_{off},QRS_{on},$QRSo_{ff}$ and T_{end}in each cycle. After identifying the ECG waves their respective amplitudes are measured with respect to the base line .This section describes application of digital filter for the removal of power line interference and baseline wander. Interference from 50Hz (in India)

AC, sometimes referred to as AC pickup or hum can pose problem while recording ECG. the sources for this interference being the AC line potential (voltages) that is unavoidably present in any clinical situation ,if for no other purpose than to light the room or power the recording unit. Baseline wandering in the ECG records produces artifactual data when measuring ECG parameters .Particularly, ST segment measures are strongly affected by this wandering. Respiration rate and electrode impedance changes due to perspiration are important sources of baseline wander in most types of ECG recordings. The frequency content in the baseline wander is usually 0.5 Hz.

5.3.1 QRS detection and R peak detection

In the ECG signal, the most prominent feature is the QRS complex. A FIDUCIL marked on the QRS complex sense the process more detail exam of the ECG signal in order to study the complete cardiac cycle. Hence In almost all the ECG interpretation method the identification of QRS complex forms the starting point. Extraction of QRS complex from cardiac cycle is complicated due to the noise present in ECG signal.

5.3.2 QRS onset &offset Detection

After the detection R peak the onset & offset of QRS complex are to be determined. The other highest slope of the R wave will be either Q peak or S peak. The other highest slope of the R wave will be max. slope value on either the upward going side or downward going side of the R wave. The other highest slope of the R wave will be either Q peak or S peak. Backward search from Rp position is carried out in window of 80 ms. If there is no zero crossing within this window the Q wave is absent. From Qi (or Ri) a backward search is carried out using threshold to locate threshold crossing point. This point is QRS on set. If there is no zero crossing within this window, the S wave is absent. This point is the QRS offset.

5.3.4 P & T Wave Detection

Next step after determining QRS fiducially is to be identifying P & T waves. These values exceed 2% of the max. slope. After the detection of P wave its onset &offset detected by searching backward & forward from P peak resp. to find the max. value of slope in order to detect T wave a window is define which is function of heart rate. T wave position is located in zero crossing adjacent to the maximum. Minimum value in this case is carried out from T wave backward & forward respectively.

6. Disease diagnosis:

The classification of arrhythmias and compared it with standard data storage and diagnosis different disease.

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