A Review: Biometric Signal Information and Techniques Available for Feature Extraction

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***Abstract*—** Heart Rate signal analysis is a trait that is widely used in medical science to monitor the heart activities of the person. To monitor the activities, the heart beat or signals are captured by using a electronic device named as Electrocardiogram i.e. ECG. This device captures the heart signals by using the electrodes that are placed on the limbs of the person. The captured signals are categorized into different waves known as P, QRS, T waves. Then these wave signals are used to extract the features and to perform classification on them in order to reach to a specific decision regarding the disease. The feature extraction and classification is the major and tedious task to perform. Therefore a large number of techniques have been developed to perform it efficiently.

The objective of this work is to represents a review to the ECG signals along with its wave type. This work also focuses to the past research work that had been done to develop the feature extraction and classification techniques for processing the ECG signals.

***Keywords*—** *Heart Rate, Heart Waves, PQRST waves, Feature Extraction, Classification.*

I. INTRODUCTION

Electrocardiogram (ECG) is an electronic device that is used in biomedical field in order to monitor the different activities of human heart. By using ECG, huge data can be collected related to pathological physiology of heart. Although, the Electrocardiograph signals are varying in nature and this is not an easy task to directly examine these [1]. Hence, it is required to implement computer based techniques to analyze the electrocardiogram signal. To scrutinize the ECG signals is a time consuming process as the signals varies constantly. The disparity in signals did not occur at a fixed interval. The analysis of visual based ECG signals are not considers as the reliable one [2]. Thus to overcome the inefficiency of visual based ECG signals, the computer base ECG techniques has been developed to explore the ECG signals. When the heart beats, it starts depolarizing to initiate contraction process. The contraction and relaxation of heart produce the electrical signal that has been forwarded to the whole body and can be measured at skin [3]. This is the major theory, on which the working criteria of ECG machine are based upon. In ECG machine, the electrodes are deployed to record the rhythmic activities of the heart. The electrodes are attached with the skin and show the recorded data on graph. To monitor the heart activity through ECG, ten types of electrical cables are attached with the human body. Out of these ten cables, 6 cables are attached to the chest and rest of the 4 is attached to the each limb. The signals recorded by the ECG delineates that there are 4 types of activities that are performed by the heart i.e. atria depolarization, atria re-polarization, ventricular depolarization and ventricular re-polarization. In ECG signal, it was observed that there is repetition of complex pattern of waveform and that have frequency of near about 1Hz [4]. The one cycle of ECG waveform contain PQRST waves. This technique is utilize to determine the pace and periodicity of heartbeats so that if there is any kind of irregularity in the heartbeat can be easily detected. The electrocardiogram may be described as a biomedical device that plots the electrical activity of heart on the screen graph. The rise and falls in the graph are represented as P-QRS-T wave. This wave has been depicted in figure number 1. Heart can be described as pumping system made up of muscles and it consist of four types of chambers [5]. The upper 2 chambers of heart are known as atria whereas lower 2 chambers are known as ventricles. Due to rhythmic contraction and relaxation of heart muscles the blood enters into the heart then move toward lungs for purification and then pumped out to whole body [6]. In the PORST wave in ECG graph, the P wave represents the electrical activity in upper heart chamber that is atria and the QRS complex defines the electrical activities performed by the heart in lower heart chamber. Then after this there is one ST segment in the waveform which represents the contraction of ventricles but no electrical current flow while this operation executed. ST part in the waveform generally forms the straight line in between the T wave and QRs wave. And in this case the T wave represents the time period, when lower chambers of heart that are ventricular are at relaxed position and preparing for upcoming contraction of muscles. On the basis of various waves that has explained above in ECG graph it is possible to diagnose cardiovascular disease with the help of ECG machine. When the heart beat is normal then the PQRST wave form made the usual pattern but in case if there is any variation in PQRST wave then it means heart operation is not common. On the basis of the rhythmic contraction and relaxation in heart muscles creates the heartbeat [7]. The distance among different waves helps in determining the

rhythm of heart and on the other hand the amplitude of pulses depicts the strength of pumping. By comparing the whole ECG waveform of patient with the standard ECG waveform of healthy person, the disease can be diagnosed. Various improvements in the technological field like had resulted in enhanced version of ECG devices. Technological advancement has revolutionized the whole world in terms of early diagnosis, cure, etc. Due to introduction of wireless transmission system, the medical healthcare system has also improved and provides large number of benefits to the society [8].

The standard waveform of ECG containing the following waves: first one is a P wave, second one is QRS complex, and third one is T wave. Because of production of electrical signal generated due to depolarization of upper chamber of heart that is atria and it should be generated before the contraction of atria muscles, then the P wave obtained. After this the QRS complex wave is produced due to the electrical signals generated during the depolarization process in lower chamber of heart and it should be before the contraction of their muscles and this takes place while depolarization in the muscles of ventricular. In the QRS complex waveform, there are further three types of waves that are as follow: Q wave, R wave, and S waves [9]. It can be clearly observe that in the PQRST waveform that QRS complex comprises three types of waveform. When the electrical signal produced while the ventricles are in recovery state from the present state of depolarization, then the T wave is obtained. This operation occur in two ventricle chambers of heart and for duration of 0.25sec to 0.35secand should takes place when the depolarization is over.

Table 1. Description and Duration of each wave in ECG waveform [24]

Feature	Description	Duration
RR interval	It is the time interval between consecutive peaks of R wave and it is inverse of R wave. Generally the heart beat of healthy person lies in between 50 -100 beats per minute.	0.6 to 1.2 sec
P wave	Whenever there is depolarization in atrial then the electrical impulse originated from the sino-atrial node and start propagation towards the Atrioventricle node and after that moves right atrium to left atrium. This yields the P wave.	80 ms
PR interval	This intervals starts from the P wave and terminates at QRS complex. This interval represents the time period taken by the electrical signal to moves from sinus node to Atrioventricle node and finally moves inside the ventricles.	120 to 200 ms
PR segment	This segment is used to create a link among P wave and QRS complex. The electrical signal generated at Atrioventricle node and start moving towards the bundle of His then bundle of branches and finally to Purkinje fibers. While executing this process no contraction takes place and just signals travels down towards the ventricles and therefore flat Electrocardiogram signal obtained at this interval. This interval is highly clinically relevant.	
QRS complex	This represents the rapid depolarization of both ventricles left as well as right ventricle. Generally the amplitude of QRS complex is much greater than the P wave.	80-120 ms
J point	This is the point at which QRS terminates and ST segment initiates. It is implemented to analyze the degree of elevation and depression.	N/A
ST segment	This segment is used to link the QRS complex with the T wave. This segment depicts the time interval when the depolarization of ventricles takes place. The ST segment is iso-electric in nature.	80 – 100 ms
T wave	This wave shows the re-polarization of lower chambers of heat that are ventricles. The absolute refractory period is the time interval when QRS complex starts to summit the T wave. In T wave the last segment is called as relative refractory time period.	160 ms
ST interval	This time interval initiates at J point and terminates at T wave.	320 ms
QT interval	This time interval initiates at QRS complex and terminates at T wave. The increased OT time interval may results in ventricular tachyarrhythmia. It varies as rate of heart beat varies.	300-430 ms
U wave	Mostly U wave is easily observed as the amplitude of its peak is very low. The U wave follows the T wave.	

II. FEATURE EXTRACTION

The heart rate recognition system on the basis of the heart rhythms is performed on the basis of the feature vectors that depict the original ECG segments. The ideal recognition system relies upon the features that are extracted from the ECG signals to pretend the difference among various

waveforms related to the various heartbeats [1]. Thus the accurate feature selection is the major task to attain the useful information. In order to extract the features in an effective manner a large number researches has been conducted till now. This section represents an overview to the work that had been done in this domain.

Zhao et al [1] proposed a new method which was based on the wavelet transform and support vector machines. This new approach was used to extract the features and to monitor the rhythm of the heart. This technique worked upon three components such as preprocessing, feature extraction and classification of ECG signals. Basically two techniques were involved in the paper which was used to achieve the feature vector of ECG data. One of the two techniques were wavelet transform which extracted the coefficients of the transform and another one is AR i.e. Auto regressive modeling which was used to attain the temporal structure of the ECG. And for the classification purpose, SVM classifier with Gaussian kernel was used. The simulations were performed to identify the accuracy of the proposed technique which was 99.68%.

Castro et al. In **[2]** proposed another approach for the feature extraction in ECG signals which was also based on the wavelet transform. The proposed algorithm first extract features from the signals and then recognized any abnormal heartbeats. The wavelet transforms can be recognized into both in frequency as well as in time domains. This study introduced a technique by using optimal mother wavelet. Thus in selection of this process; firstly denoising method has applied over the ECG signal. In the denoising process, a soft and hard threshold having a limitation of 99.99 with reconstructs ability and after that with the help of optimal wavelet function PQRST cycle has decomposed into number of coefficients vector. After doing all the processing the ECG signals were examined on the basis of the coefficients and then the approximation of the signals on the behalf of last scale level were done. The coefficient used by each cycle is categorized to three unique segments named as P-Wave, QRS complex and T waves. At last the values of the coefficients were combined to attain the feature vectors.

Mahmoodabadi et al. In **[3]** introduced a technique to extract the features from ECG signals by using Daubechies wavelet transformation technique that works upon the basis of the multi resolution wavelet transform. The signal processing was done by using the Modified Lead II. Along with this the wavelet filters and scaling function was applied to filter and scale the shape of the signals respectively. Initially, the noise was removed from the signal by deducting the wavelet coefficient which was at the higher scales. Lastly, the QRS complexes were detected where an individual complex was treated as a method to trace the peaks of each wave. The complex QRS wave was utilized to evaluate the P and T wave in the cardiac cycle. The experimental analysis has performed and the results acquired for the proposed technique are 99.18 % sensitivity and 98% prediction accuracy.

Jen et al. in [19] described an approach to determine the features of the ECG signal which was based upon the neural networks. This paper proposed an integrated system for the diagnosis of ECG. This system consisted with the cepstrum coefficient method which has used the long-term ECG signals in order to extract the features from the signals. Moreover, for the classification purpose, it has used artificial neural network. This proposed method was capable of identifying the hiding characteristics from the ECG signal, classification of signal and diagnoses of abnormalities. The experimental analysis has performed to evaluate the performance of the proposed method. For such purpose, ECG data was taken from MIT/BIH database for the verification. The results acquired showed that the accuracy rate in identifying the cardiac disease was 97.5% and it was capable in extracting the feature vectors, distinguished the difference and ECG signals classification.

Chouhan and Mehta in [20] proposed an algorithm which was used to detect QRS complexities. In this algorithm a filtering procedure based on the moving averages was used that resultant into smooth spike free ECG signal appropriate for the extraction of slope feature of ECG. Initially, slope feature was extracted from the drift corrected as well as filtered ECG signal. The extraction of slope feature has done in a way where the extracted feature signal enhanced in the area of QRS and suppressed in the non-QRS region. Consequently, the proposed method's detection rate and productivity accuracy was 98.56% and 99.18% correspondingly.

Xu et al. in [21] introduced a mechanism to investigate the QRS complex and RR interval by using the Slope Vector Waveform (SVW). The slope vector was evaluated by using the variable stage differentiation technique. Similarly, the feature extraction and non-linear amplifications process was used for better SNR ratio. The proposed method provided a fast as well as accurate search for the R location, RR interval and for the duration of QRS complex.

Alexakis et al. [22] described a new method which was used for the extraction of features and time interval from the ECG signal for the classification into normal and arrhythmic. The proposed method combined ANN i.e. artificial neural network and Linear Discriminant Analysis such as LDA for the extraction of feature. The ECG features extracted were RR, RTc, T wave skewness, amplitude and kurtosis. The above defined features were acquired through the assistance of the automatic algorithms.

Alan et al. in [23] described that chaos theory can be applied to ECG feature extraction procedure. Furthermore, the various chaos techniques like central tendency measure, phase space, correlation dimension, attractors etc. In this paper, a new ECG chaos extractor technique has proposed which applied above mentioned methods. Thus, a new semi-automatic program has been implemented in this paper which was used to extract the features of ECG. Moreover, the paper specified a graphical interface that employed several ECG files for the extraction and selection of method and saving of results. This program extracted several features from these ECG files.

III. HEART RATE PREDICTION USING VARIOUS TRAITS

Detecting heart rate on the basis of the ECG signal is a quite old method of heart rate prediction. On the basis of the above defined work in the domain of ECG signals it is concluded that the heart rate prediction using ECG signals is quite complex and time consuming process because first of all it is required to have ECG report of a patient and then the features are extracted by using feature extraction mechanism. Thus this process can also sometimes leads to the less qualitative results due to wrong choice of feature extraction mechanism. Thus after then, the heart rate prediction is done on the basis of video of the patient by observing the facial expressions, physical activities or speech of the patients. Some contributions in this domain are discussed as follows:

3.1 Heart rate prediction using physical activities

In **[5], Feng Xiao et al** depicted that the heart rate is highly affected by the physical activities thus it provided heart rate prediction model by using neural network on the basis of physical movement of one's body. The simulation was done by using the real life signals received from a healthy male person. The obtained Mean Absolute Error rate of the present work was relatively low which showed the proficiency of the proposed neural model of heart rate prediction.

Ming Yuchi et al [7] developed a physical activities based heart rate prediction scheme which had the capability to be employed in cardiopathy R&D, warning indicator for heart rate and mental activities evaluation etc. The feed forward neural network was adopted for the purpose of proposal. The simulation was done on the real life dataset of 90 minutes and was simulated continually with the interval of 30 seconds.

3.2 Heart rate prediction on the basis of the audio signals

Andreas Tsiartas et al [11] developed a method to examine the heart rate on the basis of the variations in speech of a person. The objective of this study was to analyze the way desirable system reacts with physiology of a person and to which extent the heart rate prediction can be done on the basis of the speech signals only. For this purpose, the speech and high qualitative physiology recordings were used. The concept of trigger was used to create a frustration for the user during the recording so that the user can changes his emotions as well. Then the comparison of the results was done on the basis of the pre-triggered and post-triggered regions. And on the basis of the results it was concluded that the both spectral and temporal variations have the capability to predict the heart rate with an accuracy of ~70%.

3.3 Heart rate prediction on the basis of facial expressions

Ming Zher Poh et al in **[12]** presented a novel low cost approach for evaluating the multiple physiological activities such as heart rate, pulse rate on the basis of the video by observing the color variation in the video. In this work the facial region was used for extracting the rate of pulse. And the heart rate, Respiratory rate and heart variability was sensed by using the sensors that were placed on the body of the patients. This research had some important significance in the domain of telemedicine and health prediction.

Table 2. Review to the Related Work

Domain	Authors	Approach	Simplicity	Accuracy	Prediction status
ECG signal extraction	Zhao et al.[1]	Wavelet Transform and Auto Regression	High	High	Moderate
	Castro et al.[2]	Wavelet Transform	Low	High	Low
	Mahmoodabadi et al.[3]	Multi-resolution wavelet transform	High	High	High
Various Traits	Vasu Jindal [4]	Deep Learning Mechanism	Moderate		Moderate
	Feng Xiao [5]	Neural Network	High	High	High
	Xiao et al [10]	Neural Network	High	Moderate	Moderate
	Aibek Ryskliyev et al [9]	Linear Model	High	High	High

IV. CONCLUSION

ECG signal processing has gained the attention of various research scholars due to various reasons such as to develop the more enhanced and effective feature extraction mechanism, to develop a tactic to capture the ECG signals such as via video, physical activities, facial expressions etc. This study concludes a brief overview to the ECG signals and PQRST waves. The techniques that are used to extract the features and to perform classification are also covered under this study. After having a review to these traditional techniques, it is observed that the heart rate prediction on the basis of ECG signals can be done by using various traits such as human facial expressions, physical activities performed by a person, by using a video etc. Thus it is concluded that the heart rate prediction on the basis of the video is the most effective way to predict the accurate results.

Therefore in near future, more amendments could be done on frame extracting strategies from the video so that the video with more enhanced quality can be obtained for further processing. Along with this it has been seen that various optimization techniques were used by authors to achieve the optimized results. Accordingly, the advanced optimization techniques can be used for future work.

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