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Review on ECG Signal Entropy Assessment and PR Intervals Allocation in Malignant Ventricular Arrhythmias

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Abstract- This work is an attempt to discuss and investigate various techniques of extracting and selecting the vital features from the ECG signal in order to analyze the ECG signal automatically. Feature extraction, classification of feature and optimization of extracted feature are some of the common steps of automatically analyze the ECG data. Morphological and statistical features of the ECG signals play very important role in detecting the heart related diseases. A morphological feature gives good result in arrhythmia classification while statistical feature are also useful because of variation in ECG signal for different patients.

Keywords- Feature Extraction, SVM, PSO, ECG, DWT.

I. INTRODUCTION

Electrocardiogram (ECG) is a nearly periodic signal that reflects the activity of the heart. A lot of information on the normal and pathological physiology of heart can be obtained from ECG. However, the ECG signals being non-stationary in nature, it is very difficult to visually analyze them. Thus the need is there for computer based methods for ECG signal Analysis. A lot of work has been done in the field of ECG signal Analysis using various approaches and methods. The basic principle of all the methods however involves transformation of ECG signal using different transformation techniques including Fourier Transform, Hilbert Transform, Wavelet transform etc. Physiological signals like ECG are considered to be quasi-periodic in nature. They are of finite duration and non stationary. Hence, a technique like Fourier series (based on sinusoids of infinite duration) is inefficient for ECG.

On the other hand, wavelet, which is a very recent addition in this field of research, provides a powerful tool for extracting information from such signals. There has been use of both Continuous Wavelet Transform (CWT) as well as Discrete Wavelet Transform (DWT). However CWT has some inherent advantages over DWT. Unlike DWT, there is no dyadic frequency jump in CWT. Moreover, high resolution in time-frequency domain is achieved in CWT [3].

Transmission of ECG often results in the corruption of signal due to introduction of noise. [5] Various factors responsible for introduction of noise include poor channel conditions, Baseline wander (caused by respiration), 50 or 60 Hz power line interference etc. Analyzing such a noisy signal is bound to give erroneous results. Thus the signal is first made free of noise, a process called denoising or rather we may call it enhancement. A number of methods have been incorporated for enhancement ECG signal. These include use of filter banks, neural network, adaptive filtering etc. Empirical Mode Decomposition is a recent development which provides a powerful tool for decomposing a signal into a finite number of IMFs (Intrinsic Mode Functions). Empirical Mode Decomposition (EMD) has been used in a number of literature for R-peak detection as well as enhancement. The process incorporated by us can be shown by the following block diagram:

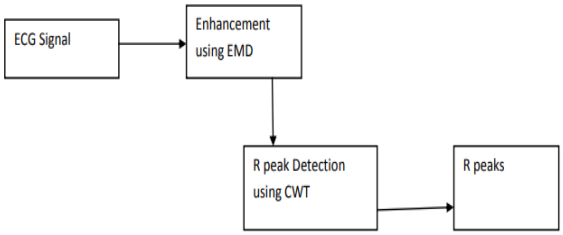

Fig 1. Block diagram.

Electrocardiogram (ECG) is a noninvasive technique that is used as a diagnostic tool for cardiovascular diseases [1]. ECG signal is widely used as a fundamental tool for the detection and diagnosis of heart disorders. ECG is the record of variation of bioelectric potential with respect to time as the human heart beats. It provides valuable information about the functional aspects of the heart and cardiovascular system. Since ECG is the most commonly recorded signal for the patient monitoring and examination process, it is important to be reliably and quickly detect the cardiac disorders. ECG can be recorded easily with the help of surface electrodes on the limbs or chest. It is considered a representative signal of cardiac physiology, useful in diagnosing cardiac arrhythmia [2-5].

Abnormality of the ECG shape is usually called arrhythmia. Arrhythmia is a common term for any cardiac rhythm that differs from normal sinus rhythm [4].Therefore; a powerful computer aided diagnosis (CAD) system is required for the early detection of cardiac abnormality [5].

II. EMPIRICAL MODE DECOMPOSITION

A new non-linear technique, called Empirical Mode Decomposition method, has recently been developed by N.E.Huang et al for adaptively representing non-stationary signals as sums of zero mean AM-FM components [6]. EMD is an adaptive, high efficient decomposition with which any complicated signal can be decomposed into a finite number of Intrinsic Mode functions (IMFs). The IMFs represent the oscillatory modes embedded in the signal, hence the name Intrinsic Mode Function. The starting point of EMD is to consider oscillations in signals at a very local level. It is applicable to non-linear and non-stationary signal such as ECG signal.

An Intrinsic Mode function is a function that satisfies two conditions [6]:

- The number of extrema and the number of zero crossings must differ by at most 1.
- At any point the mean value of the envelope defined by maxima and the envelope defined by minima must be zero.

1. Sifting Process:

Some of the assumptions made for decomposition are:

- The signal has at least two extrema: one maximum and one minimum
- The characteristic time scale is defined by the time lapse between the extrema.
- If the signal has no extrema but has inflection points, then the signal can be differentiated one or more times to find the extrema. The basic principle of this method is to identify the intrinsic oscillatory modes by their characteristic time scales in the data empirically and then decompose the data. A systematic way to extract the IMFS is called the Sifting Process and is described below:
  - Identify all the extrema of x(t).
  - Interpolate between minima, ending up with a signal min (t) and similarly between extrema to give max (t).
  - Compute the average: e(t)= (min (t) + max (t))/2

III. RESEARCH MOTIVATION

An ECG is generated by a nerve impulse stimulus to the heart. The current is diffused around the surface of the body. The current at the body surface will build on the voltage drop, which is a couple of μV to mV with an impulse variation. Usually, this is very small amplitude of impulse, which requires a couple of thousand times of amplification. Arrhythmias are caused by abnormalities in the conduction system of the heart. So, one of the most effective tools for arrhythmia diagnosis is the detection of ECG signals.

IV. FEATURE EXTRACTION

Extraction of various features from the ECG signal is essential steps in ECG signal analysis. Detecting P, Q, R, S and T wave (QRS complex) in ECG signal comes under the feature extraction. This wave gives a lot of information about the condition of heart which help doctors to diagnose the disease. One of the common methods of detecting the QRS complex is to use the non-linear filtering [4] which is less complex and require less time also.

But this method is not able to work in case of frequency variation occurs in QRS complex and hence give poor performance in this condition. Due to the noise, frequency band of QRS complex overlap the frequency band of noise which produce false positive and negative.

1. Signal Preprocessing:

The ECG signal is contaminated with noise of various kinds, which can be classified as [15]:

- Power grid interference at 50 ± 2 Hz (or 60 Hz).
- Noise from loss of contact between skin and electrodes.
- Disturbances due to patient movement and electrodes.
- Electromyography noise due to the electrical activity of the muscles.
- Baseline diversion, usually caused by breathing.
- Noise of the device that performed the ECG recording.
- Noise generated by other electrical equipment.
- Quantization and sampling noise.
- Disturbances due to signal processing.

V. LITERATURE SURVEY

Muhammad Wasimuddin et al. [1] Electrocardiogram (ECG) gives essential information about different cardiac conditions of the human heart. Its analysis has been the main objective among the research community to detect and prevent life threatening cardiac circumstances. Traditional signal processing methods, machine learning and its subbranches, such as deep learning, are popular techniques for analyzing and classifying the ECG signal and mainly to develop applications for early detection and treatment of cardiac conditions and arrhythmias.

Fatma Murat et al. [2] Deep learning models have become a popular mode to classify electrocardiogram (ECG) data. Investigators have used a variety of deep learning techniques for this application. Herein, a detailed

examination of deep learning methods for ECG arrhythmia detection is provided.

Varun Gupta et al. [3] An Electrocardiogram (ECG) is a primary and most prevalent non-invasive test performed on the subjects' (i.e. patients') with suspected heart problems. It helps in diagnosing important cardiological status of the subject's heart i.e. normal or abnormal by investigating rhythm of the heart. This interpretation is not always possible using naked eyes, especially for minute aberrations. Therefore, advanced feature extraction methods are required for investigating these minute differences that might be a challenge to be detected by the human eye.

LipingXie, et al. [4] Cardiovascular diseases (CVDs), including asymptomatic myocardial ischemia, angina, myocardial infarction, and ischemic heart failure, are the leading cause of death globally. Early detection and treatment of CVDs significantly contribute to the prevention or delay of cardiovascular death. Electrocardiogram (ECG) records the electrical impulses generated by heart muscles, which reflect regular or irregular beating activity. Computer-aided techniques provide fast and accurate tools to identify CVDs using a patient's ECG signal, which have achieved great success in recent years.

MohanadAlkhodari et al. [5] In this paper, further investigations into a simpler automated use of Independent Component Analysis (ICA) in the process of Fetal ECG (FECG) extraction are performed. Extracting FECG signals through abdominal electrodes helps clinicians in diagnosing the overall health of the fetus non-invasively.

Shin Jae Kang et al. [6] We propose a practical system design for biometrics authentication based on electrocardiogram (ECG) signals collected from mobile or wearable devices. The ECG signals from such devices can be corrupted by noise as a result of movement, signal acquisition type, etc. This leads to a tradeoff between captured signal quality and ease of use.

Geetanjali Srivastava et al. [7] This paper proposes a signal adaptive algorithm for multi-resolution analysis based on analytic signal matched filter bank (SMFB) to decompose time variant biomedical signals (e.g. ECG) into narrow bands such that each band has only one harmonic frequency component of the original ECG signal.

Rizwan Qureshi et al. [8] Electrocardiogram (ECG) signal is the electrical activity of the human heart. The ECG contains important information about the overall performance of the human cardiac system. Therefore, accurate examination of the ECG signal is very important but challenging task. ECG signal is often very low amplitude and contaminated with different types of noises due to its measurement process e.g. power line interference, amplifier noise and baseline wander.

Yeldos A. Altay et al. [9] The paper presents a comparative analysis of frequency-time methods for processing ECG signals. Initially for a comparative analysis of methods the structural feature of the morphology of ECG signals is analyzed.

Lukas Smitalet al. [10] Objective: Nowadays, methods for ECG quality assessment are mostly designed to binary distinguish between good/bad quality of the whole signal. Such classification is not suitable to long-term data collected by wearable devices. In this paper, a novel approach to estimate long-term ECG signal quality is proposed. Methods:

AchrafDaoui et al. [11] In this paper, we propose an efficient method for the compression and reconstruction of the large-size 1D electrocardiogram (ECG) signal. In this method, we use Thebichef moments calculated by the modified Gram-Schmidt ortho-normalization process with the use of a full large-sized signal (N=8000) in the reconstruction and compression process.

Hsien-Wei Tseng et al. [12] Nowadays, with the advanced technological development and the higher attention on health issue, many wearable devices are designed to value health care. When you wear the devices which combine with medical equipment, you do not need to go to hospitals to take physical examination in particular if you just want to check your physical conditions initially.

Table 1.

S.N.	Author name	Methodology
1.	Wasimuddin, M., Elleithy, K., Abuzneid, A. S., Faezipour, M., &Abuzaghleh, O. (2020).	Machine learning techniques SVM
2.	Murat, F., Yildirim, O., Talo, M., Baloglu, U. B., Demir, Y., & Acharya, U. R. (2020).	DNN
3.	Gupta, V., Mittal, M., Mittal, V., &Saxena, N. K. (2021).	FFT
4.	Xie, L., Li, Z., Zhou, Y., He, Y., & Zhu, J. (2020).	Computer-aided techniques
5.	Mirza, S., Bhole, K., & Singh, P. (2020, February).	Independent Component Analysis (ICA)
6.	Cherupally, S. K., Yin, S., Kadetotad, D., Srivastava, G., Bae, C., Kim, S. J., &Seo, J. S. (2020).	Cross correlation
7.	Srivastava, G. (2021)	Multi-resolution analysis

VI. CLASSIFICATION

In the literature, there are various classifiers that have been utilized for ECG analysis and classification tasks. According to the recent studies reviewed in this paper, these classifiers can be mainly grouped into categories such as artificial neural networks (ANNs), LDA, k nearest neighbour (kNN), support vector machine (SVM), decision tree (DT), and Bayesian classifiers. All of these common approaches and other uncommon approaches are explained in the next subsections.

1. Artificial Neural Networks (ANN):
An ANN is a mathematical model that is inspired by biological neural networks. It includes interconnected artificial neurons, with the interconnections associated with adjustable weights; the neurons consist of input, output and/or hidden layer(s); this approach is one of the widely used pattern classifiers. ANNs aim to solve both linear classification and non-linear classification problems with various network structures and learning algorithms.

2. Support Vector Machine (SVM):
SVM is a widely used tool for solving binary classification problems because of its outstanding generalization performance. The main idea of the SVM is to find a maximum margin between the training data and the decision boundary [8]. Support vectors, which are the training samples that are closest to the decision.

VII. CONCLUSION

ECG signal carries some vital information about the heart and it is one of the important tool for the doctors to for diagnosing the heart related diseases. In the past a lot of work has been presented by various researcher to extract the features from the ECG signal so that the analysis of ECG become automate and easier. The analysis of ECG signal depends upon the accurate detection of various features of ECG signal. In this review paper some of the important algorithm of ECG feature extraction presented in the past has been discussed. From the discussion it is clear that wavelet transform is one of the important tools for extracting out QRS complex and other features from the ECG signal.

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