

# Chapter 9

## Trends of ECG Analysis and Diagnosis

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### ABSTRACT

*Any biomedical signal has the specialty in terms of the remoteness and nature of their source as an advantage over other natural signals. The analysis of biomedical signal plays a significant role in medical, and to be exact cardiological decision making, provided, the subject information is accurate and reliable. Normally experienced and trained medical practitioners, are known to study and know them better, but in this age of technology computerized expert system are better for long term continuous monitoring and automatic decision making. This led to evolution of biomedical engineering as a separate wing where parts of engineering under automatic signal processing and analysis studies are done. ECG being the most vital physiological signal, its acquisition technique, noise and artifacts elimination methodologies are discussed in this chapter. A brief description on ECG and its usage as biometric and analysis of Atrial Fibrillation is presented.*

### INTRODUCTION

This chapter contains the basics of the ECG providing a brief summary of the etiology of the electrocardiogram, together with an overview of the mechanisms that lead to the manifestation of both normal and abnormal morphologies on the many different vectors that constitute the clinical ECG leads. To add up the applications like biometrics and atrial fibrillation have been discussed as well. After an overview of the cardiological

data collection variables considered in any signal processing analysis will go to mathematical analysis of the normal and abnormal waveforms that may be encountered, and some empirical models available for describing these waveforms (or their underlying processes). To provide the idea of designing own ECG data collection system and analysis stage along with knowledge of the hardware acquisition, the steps are discussed. These consist of the various methods of ECG acquisition, storage, transmission, and representation with

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the main steps for designing and implementing an ECG acquisition system with attention to the possible sources of error, particularly from signal acquisition, transmission, and storage.

Then an outline of noise, artifacts and other ECG statistics which are the main problems of the researchers to quantify the ECG are given based on beat-to-beat timing sequences. This serves as introduction to many different linear stationary and nonstationary qualities of the ECG, together with relevant metric selection for evaluation of these properties. An insight into different relevant processes to the different recording situations that may be encountered is discussed here. These may vary based on activity, demographics and medical conditions. It is important, although difficult; to differentiate between the concept of the nonstationary and the nonlinear nature of the ECG, since the application of a particular methodology or model will depend on prior beliefs concerning the relevance of these paradigms.

An overview of linear filtering methods from a generalized viewpoint of matrix transformations is provided next. These are to project observations into a new subspace whose axes are either a priori defined i.e. Fourier-like decompositions or discovered from the structure of the observations themselves. Then the nonlinear ECG model-based techniques with an overview of how to apply nonlinear systems theory and common pitfalls encountered with such techniques are discussed.

For analysis, the signal should be processed to extract the relevant features post filtering. The feature extraction part is not covered in this chapter. Instead a brief description of ECG classification technique and biometric analysis is given. ECG based abnormality detection depends upon feature extraction and a featured dependent rule base generation which may be a supervised or unsupervised approach. Some important quality factors of pattern classification algorithm are also mentioned along with ECG and analysis of Atrial Fibrillation.

## **Basics of ECG**

The heart is comprised of muscle (myocardium) that is rhythmically driven to contract and hence drive the circulation of blood throughout the body. Before every normal heartbeat, or systole, a wave of electrical current passes through the entire heart, triggering myocardial contraction. The pattern of electrical propagation is not random, but spreads over the structure of the heart in a coordinated pattern which leads to an effective, coordinated systole. This results in a measurable change in potential difference on the body surface of the subject. The resultant amplified (and filtered) signal is known as an electrocardiogram (ECG).

Various factors affect the ECG starting from abnormalities of cardiac conducting fibers, metabolic abnormalities (including a lack of oxygen, or ischemia) of the myocardium, to the macroscopic abnormalities of the normal geometry of the heart. ECG analysis is a routine part of any complete medical evaluation, due to the heart's essential role in human health and disease, and the relative ease of recording and analyzing the ECG. Understanding the basis of a normal ECG requires appreciation of four phenomena. They are, the electrophysiology of a single cell, how the wave of electrical current propagates through myocardium, the physiology of the specific structures of the heart through which the electrical wave travels, and last how that leads to a measurable signal on the surface of the body, producing the normal ECG.

## **Cardiac Electrical Activity**

The P wave is the initial wave of a cardiac cycle (Fig.1). It represents activation of the atria. The middle section of the P wave represents completion of right-atrial activation and initiation of left-atrial activation. The final section of the P wave represents completion of left-atrial activation. The next group of waves recorded is the QRS complex, representing the simultaneous activation of the

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