Chapter 6
ECG Data Analysis

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ABSTRACT

Any biological signal has the specialty over the other physical signals in terms of the remoteness of their source. As the analysis of biological signal plays an important role in medical decision making, the subject information should be accurate and reliable. Though these types of signals are better studied by trained and experienced medical practitioners, long term continuous monitoring and automatic decision making is better done by a computerized expert system. So it becomes a part of engineering under automatic signal processing and analysis studies. ECG being the most vital physiological signal, its acquisition technique, noise and artifacts elimination methodologies are discussed in this chapter. A brief description on automatic classification techniques is also given.

INTRODUCTION

The initial part of the chapter contains the Physiological Basis 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 After an overview of the variables to be considered in any ECG data collection exercise then we 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).

Next we go for the various methods of ECG acquisition, storage, transmission, and representation with 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. This is mainly to provide idea to design own ECG collection system and analysis stage and knowledge of the hardware used to acquire the ECG.

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Then an over view of ECG statistics, noise, artifacts etc. are given which are the main problems of the researchers to quantify the ECG (and derived beat-to-beat timing sequences).Here only an outline of these things are provided. This will introduce the reader to many different linear stationary and nonstationary qualities of the ECG, together with a selection of relevant metrics for evaluating these properties and an insight into possible approaches which are relevant to the different recording situations one may encounter (that vary based on activity, demographics and medical condition). 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.

Then an idea on linear filtering methods presented from the generalized viewpoint of matrix transformations to project observations into a new subspace whose axes are either a priori defined (as in Fourier-like decompositions) or discovered from the structure of the observations themselves. This followed by nonlinear ECG model-based techniques with an overview of how to apply nonlinear systems theory and common pitfalls encountered with such techniques.

A ECG signal after proper filtering is suitable for analysis. For analysis, the signal should be processed to extract the relevant features. The feature extraction part is not covered in this chapter. Finally a brief description of ECG classification technique 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.

Basics of ECG

Before going to the data analysis of the electrocardiogram (ECG) it is important to first understand the physiological basis of the ECG, to review measurement conventions of the standard ECG, and to review how a clinician uses it for patient care. 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, or sometimes EKG).

A various factors affect the ECG, including abnormalities of cardiac conducting fibers, metabolic abnormalities (including a lack of oxygen, or *ischemia*) of the myocardium, and 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 in a noninvasive manner. Understanding the basis of a normal ECG requires appreciation of four phenomena: 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 initial wave of a cardiac cycle represents activation of the atria and is called the P wave (Figure1). 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

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