

Chapter VII

ECG Processing

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ABSTRACT

This chapter describes methods for preprocessing, analysis, feature extraction, visualization, and classification of electrocardiogram (ECG) signals. First we introduce preprocessing methods, mainly based on the discrete wavelet transform. Then classification methods such as fuzzy rule based decision trees and neural networks are presented. Two examples - visualization and feature extraction from Body Surface Potential Mapping (BSPM) signals and classification of Holter ECGs – illustrate how these methods are used. Visualization is presented in the form of BSPM maps created from multi-channel measurements on the patient's thorax. Classification involves distinguishing between Holter recordings from premature ventricular complexes and normal ECG beats. Classification results are discussed. Finally the future research opportunities are proposed.

INTRODUCTION

Electrocardiogram (ECG) analyses have been used as a diagnostic tool for decades. Computer technology has led to the introduction of ECG analysis tools that aim to support decision making by medical doctors. This chapter will introduce the reader to ECG processing as an example of a data-mining application. Basic methods of preprocessing, analysis, feature extraction, visualization, and classification will be described. First, clinical features of ECGs are presented. These features are the basic characteristics used in temporal analysis of ECGs. Then four types of ECG signal measurement are briefly described.

The next section focuses on preprocessing, analysis, and feature extraction. Since the measured ECG signal contains noise, the first step is denoising. Then we introduce the wavelet transform as a method for detecting the characteristic points of ECG. Feature extraction is a necessary step before classification can be performed. The quality of the classification depends strongly on the quality of the features. We present an overview of techniques for extracting ECG diagnostic and morphological features. Feature extraction from BSPM is shown as an example. The final step in ECG processing is classification. In the section on classification, several supervised and unsupervised methods are described. Classification of Holter ECGs is presented as an example, and we discuss the results achieved using the algorithms presented here. The chapter concludes with a look at future trends and problems to be addressed.

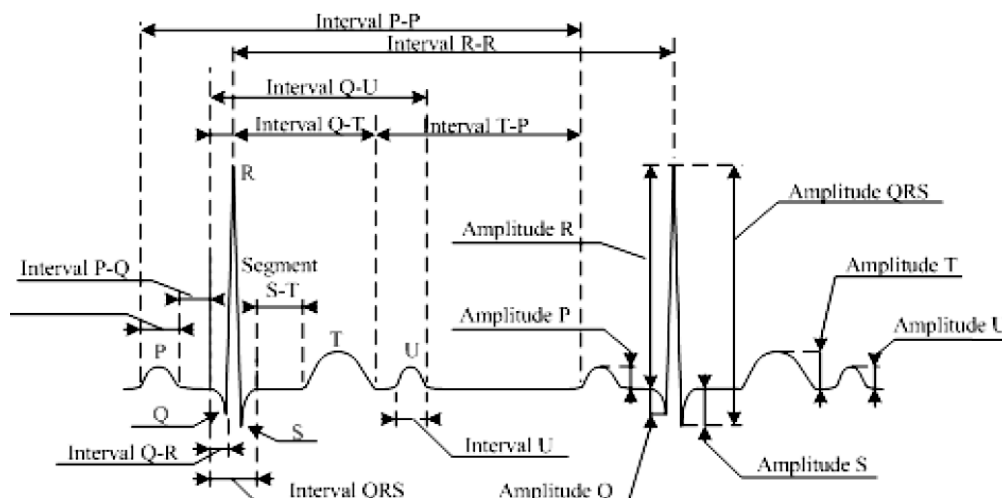
THE PHYSIOLOGICAL BASIS OF ECGS AND ECG MEASUREMENT

ECG signals

An electrocardiogram (ECG) is a recording of the electrical activity of the heart in dependence on time. The mechanical activity of the heart is linked with its electrical activity. An ECG is therefore an important diagnostic tool for assessing heart function.

ECG signals, measurements of which will be described here, can provide a great deal of information on the normal and pathological physiology of heart activity. An ECG as an electrical manifestation of a human activity is composed of heartbeats that repeat periodically. Several waves and interwave sections can be recognized in each heartbeat. The shape and length of these waves and interwave sections characterize cardiovascular diseases, arrhythmia, ischemia and other heart diseases. Basic waves in ECG are denoted by P, Q, R, S, T, and U - see Figure 1. The denotation (and length) of the intervals and segments is derived from these. The time axis uses the order of milliseconds, while the potential axis uses the order of mV.

Figure 1. ECG temporal analysis – parameters of a heartbeat



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