

Chapter 13

Automatic Arrhythmia Detection

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ABSTRACT

In the present chapter, the authors have developed a tool for the automatic arrhythmias detection, based on time-frequency features and using a Support Vector Machines (SVM) as classifier. Arrhythmia Database Massachusetts Institute of Technology (MIT) has been used in the work in order to detect eight different states, seven are pathologies and one is normal. The unions of different blocks and its optimization have found success rates of 99.82% for RR' interval detection from electrocardiogram (PQRST waves), and 99.23% for pathologic detection. In particular, the authors have used wavelet transform in order to characterize the wave of electrocardiogram (ECG), based on Biorthogonal family, achieving the most discriminative coefficients. A discussion on arrhythmia ECG classification methods is also presented in this paper.

INTRODUCTION

Nowadays, cardiovascular diseases are one of most important causes of death, with a great repercussion on the health assistance budget. For instance, to obtain an early exact cardiovascular diagnosis is one of the most important missions for the physicians.

Blood cannot pump effectively when the heart does not beat properly. Therefore the lungs, brain

and all other organs cannot work properly and may shut down or be damaged.

Cardiology departments have become one of the most important areas within Health Services all over the world, due to the number of deaths caused by cardiology related problems. In particular, in Spain, according to the National Statistics Institute (INE), approximately a third of the total number of fatalities had its origin in a cardiac disease. As the single largest cause of death it cannot be ignored.

DOI: 10.4018/978-1-61520-893-7.ch013

Nevertheless, research carried out in this area to date is considered to be insignificant, bearing in mind the high rate of deaths caused by cardiac diseases. European Union countries invest on average a minimal value of 3%, considerably less than countries such as the USA (6.8%) or South Korea (5.4%).

The ECG is the graphic description of the heart's electric activity registered from the body surface in exquisite detail. This is a basic element in the diagnosis of different heart diseases. This diagnosis depends on the medical experience. Normally a big knowledge is needed to obtain great results.

Some of the reasons of identification error are: signal with no good quality; details under noise or miniature details such as human subjectivity.

Therefore, the objective of this present work is to design and implement computer aided software for detecting arrhythmias based on the time-frequency features and using an automatic classification system. The term arrhythmia refers to any change from the normal sequence of electrical impulses. The electrical impulses may happen too fast, too slowly, or erratically causing the heart to beat too fast, too slowly, or erratically. This idea is based on the feature extraction from Electrocardiogram (ECG) signal, using physicians as supervised knowledge for labeling ECG signals. The function of these tools is to help on medical tasks against the prevention of cardiovascular diseases.

BACKGROUND

In the 60's the ECG analysis had a wide number of studies about its process in different ways and for different applications, for example, some of them apply mathematical or statistical concepts.

Most cardiovascular diseases can be diagnosed by the analysis of the significant time intervals in the ECG signal. The ECG features extracted can determine whether a patient presents any kind of

cardiac pathology or not. However, in order to extract these values a previous signal processing is required to delete noise and to make the analysis lighter. The common noise sources are: baseline wander, power line interference and muscle noise. Baseline wander, or stranger low-frequency high-bandwidth components, can be caused by: perspiration (effects electrode impedance), respiration and body movements. These noises can cause problems to analysis, especially when examining the low-frequency ST-T segment.

On the frequency domain, the main information is placed under 35 Hz. Power line normally affect over 50 and 60 Hz and the muscle noisy can be approximated as white noise because his frequency spectrum is practically plane.

The inherent morphology of the electrocardiographic (ECG) signal is a key factor to determine if the reliable feature detection can be made. As a non-stationary signal, ECG has to be pre-processed using frequency adaptive tools. Several techniques have been used to perform the detection of these features over the last decades, such as the Short Time Fourier Transform (STFT) or the Wavelet transform.

In the arrhythmias detection there are two main kinds for the feature extraction. On the one hand, features extracted directly from the ECG signal, time, sizes, areas, delays, etc. And on the other hand, features extracted from domain transforms. Both methods will be discussed in this present work (Mallat, 1998; Kunzmann et al. 2002; Alonso et al., 1999; Moraes et al., 2002; Bahoura et al., 1997; Hosseini & Reynolds, 2001; Zimmerman & Povinelli, 2004).

The block diagram of both approaches is very similar; the difference is the feature extraction module. In the Figure 1, we can see a block diagram of the whole classification system.

As shown, after extracting the features from the entire database, a first training stage is obtained. Through this model system a new block of features is applied to see the answer of the model. If it this solution is optimal, the final Classifier

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