Intelligent Classifier for Atrial Fibrillation (ECG)

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INTRODUCTION

This chapter is focused on the analysis and classification of arrhythmias. An arrhythmia is any cardiac pace that is not the typical sinusoidal one due to alterations in the formation and/or transportation of the impulses. In pathological conditions, the depolarization process can be initiated outside the sinoatrial (SA) node and several kinds of extra-systolic or ectopic beatings can appear.

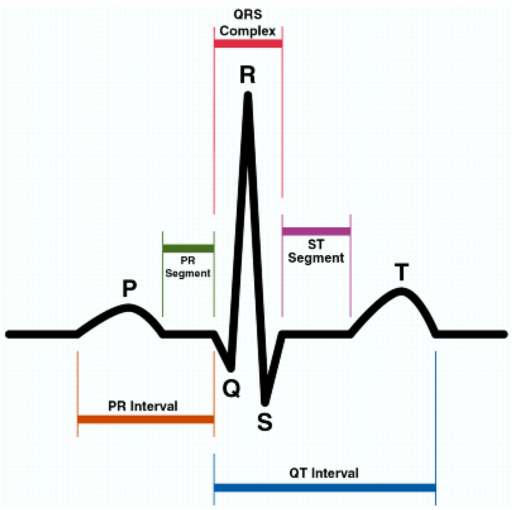
Besides, electrical impulses can be blocked, accelerated, deviated by alternate trajectories and can change its origin from one heart beat to the other, thus originating several types of blockings and anomalous connections. In both situations, changes in the signal morphology or in the duration of its waves and intervals can be produced on the ECG, as well as a lack of one of the waves.

This work is focused on the development of intelligent classifiers in the area of biomedicine, focusing on the problem of diagnosing cardiac diseases based on the electrocardiogram (ECG), or more precisely on the differentiation of the types of atrial fibrillations. First of all we will study the ECG, and the treatment of the ECG in order to work with it, with this specific pathology. In order to achieve this we will study different ways of elimination, in the best possible way, of any activity that is not caused by the auriculars. We will study and imitate the ECG treatment methodologies and the characteristics extracted from the electrocardiograms that were used by the researchers that obtained the best results in the Physionet Challenge, where the classification of ECG recordings according to the type of Atrial Fibrillation (AF) that they showed, was realised. We will extract a great amount of characteristics, partly those used by these researchers and additional characteristics that we consider to be important for the distinction mentioned before. A new method based on evolutionary algorithms will be used to realise a selection of the most relevant characteristics and to obtain a classifier that will be capable of distinguishing the different types of this pathology.

BACKGROUND

The electrocardiogram (ECG) is a diagnostic tool that measures and records the electrical activity of the heart in exquisite detail (Lanza 2007). Interpretation of these details allows diagnosis of a wide range of heart conditions. The QRS complex is the most striking waveform within the electrocardiogram (Figure 1). Since it reflects the electrical activity within the heart during the ventricular contraction, the time of its occurrence as well as its shape provide much information about the current state of the heart. Due to its characteristic shape it serves as the basis for the automated determination of the heart rate, as an entry point for classification schemes of the cardiac cycle, and often it is also used in ECG data compression algorithms.

Figure 1. Diagram of the QRS complex



A normal QRS complex is 0.06 to 0.10 sec (60 to 100 ms) in duration. In order to have a signal clean of auricular activity in the ECG, we will analyse and compare performances from these two different approaches:

1. To remove the activity of the QRS complex, subtracting from the signal a morphological average of its activity for every heart beat,
2. To detect the TQ section among heart beats (which are zones clean of ventricular activity) and analyse only data from that section.

There exists a great variety of algorithms to carry out the extraction of the auricular activity from the electrocardiogram such as the Thakor method (a recurrent adaptive filter structure), adaptive filtering of the whole band, methods based on neural-networks, spatial-temporal cancellation methods and methods based on Wavelets or on the concept of Principal Component Analysis (PCA) (Castells et al. 2004, Gilad-Bachrach et al. 2004, Petrutiu et al. 2004).

A fundamental step in any of these approaches is the detection of the QRS complex in every heart beat. Software QRS detection has been a research topic for

Figure 2. The segments are shown detected by the algorithm on the two channels of a registration. In green the end of the wave T is shown, and in red the principle of the wave Q. Therefore each tract among final of wave T (green) and wave principle Q (red), it is a segment of auricular activity. The QRST complex is automatically detected with good precision.