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Research on Atrial Fibrillation Data by Principal Component Analysis

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Abstract. In the case of Gauss distribution, the principal component analysis is equivalent to the maximum amount of information in the output signal. The theory and practice of principal component analysis (PCA) is concise, and the results coincide with the objective reality, making it widely applied in the fields of economy, society and engineering. First, we discuss the characteristics of the room electric signal, clarify the significance of the estimation of the main frequency. Secondly, we study the mathematical modeling method of the main frequency estimation, improve the Furiour Algorithm and the harmonic decomposition method, and propose a multiple signal classification algorithm. Finally, we compare the characteristics of different algorithms, and estimate the accuracy of the main frequency, and select the appropriate main frequency estimation algorithm to help the electrocardiologists determine the target ablation risk frequency and improve the efficiency of ablation operation.

Introduction

The treatment of atrial fibrillation includes drug treatment and non drug treatment. The American Institute of cardiovascular disease (American College of Cardiology), the American Heart Association (American Heart Association) and the European Society for cardiovascular disease (Europe Society of Cardiology) in the 2006 edition of the "ACC/AHA/ESC" in the treatment of atrial fibrillation guide [1] pointed out that drug treatment on the whole is still the first choice of in treatment of atrial fibrillation. But the two treatment strategies in the primary end point was difference between the two groups in overall mortality is consistent, there was no improvement in symptoms between the two groups had significant difference.[2] In theory, the maintenance of sinus rhythm should be able to reduce mortality in patients with atrial fibrillation, benefit patients, and the results of clinical trials, on the other hand, the occurrence of adverse reaction of anti arrhythmic drugs itself high rate. Therefore, not the maintenance of sinus rhythm will not bring more benefits, but the existing antiarrhythmic drugs are not safe and effective. In fact, maintaining sinus rhythm is related to the reduction of mortality.[3] If there is a way to effectively and safely suppress atrial fibrillation, maintaining sinus rhythm will surely improve patient's quality of life, reduce mortality and make patients really benefit.

Non - drug treatment includes surgical treatment and instrument treatment. Early surgical treatment for left atrial isolation (Left atrial isolation), corridor operation (Corridoroperation) although it can achieve sinus arrhythmias, but still in the atrium in patients with atrial fibrillation or electro mechanical static state, can not restore atrial pump function, also can not prevent the formation of thrombus, which is seldom used today. At present, the main surgical procedure for atrial fibrillation surgery is still the maze operation (Surgical maze procedure).[4] In Europe, the long-term success rate of maze surgery is 70.95%, and postoperative thromboembolic events are significantly reduced. However, because of its large trauma and the need for cardiopulmonary bypass, the clinical application is limited.

Electrophysiology of the Heart

The cardiac conduction system consists of sinoatrial node, internode bundle, atrioventricular node, atrioventricular bundle, left and right atrioventricular bundle branches and Purkingje fibers. The sinoatrial node is the origin of normal cardiac impulse, which is located at the junction between the

superior vena cava and the right ventricle, as shown here.[5] The internode bundle is the conduction path between the sinoatrial node and the atrioventricular node, which is divided into three conduction bundles of the anterior, middle and posterior. The atrioventricular node, which are located at the left and right intima of the interval.[5] The left bundle branch in the left ventricular septum is divided into two bundles of anterior and posterior branches. The right bundle branch descends along the right side of the ventricular septum until the apex is at the tip of the heart that begins to branch into Purkinje fiber. The branches of the two sides of the ventricle are divided into myriads of Purkinje fibers and myocardial fibers.

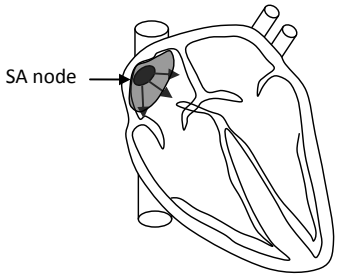

Figure 1. Excited state of heart

Under normal circumstances, the heart excited originated in the sinoatrial node, the node between the beam and the conduction system by the atrial atrial depolarization, then through the channel between the normal atrioventricular to the atrioventricular node slow afferent atrioventricular bundle and the left and right bundle branch, Purkinje fiber, and finally achieve the ventricular depolarization in ventricular myocytes. When the cardiac excitation is produced outside the sinoatrial node, or the abnormal conduction of cardiac conduction, or the change of cardiac rhythm and speed caused by both of them, and the change of conduction time and sequence, it is commonly referred to as arrhythmia.

Research Progress on Signal Processing Technology

Blind source separation and blind source extraction are used in blind processing. The premise condition of using the method: the real wave and wave signal can be considered to be statistically independent; real waves and waves are non Gauss; the observed body surface ECG signal can be regarded as the combination of instantaneous real wave and wave mixing chamber, the unknown coefficient depends on the electrode placement position and body tissue conduction rate. Rieta J [7] and other scholars put forward the fast independent component analysis algorithm (Fast Independence Component Analysis, Fast ICA); Casterlls F [8] and other scholars research using time correlation, AF signal known real (Atrial Action, AA) dynamic and dynamic (Ventricular action VA) the probability distribution characteristic, proposed a method for blind separation based on maximum likelihood source. Blind methods are able to find the atrial fibrillation wave after separation of the signal from the source. However, the precondition of this method is harsh. As a complex electrophysiological process, atrial fibrillation is often difficult to meet many prerequisites. Therefore, the feasibility and effectiveness of the blind signal processing method in practical application is very difficult to guarantee.

The occurrence of atrial fibrillation is closely related to atrial effective refractory period, electrical excitation in the conduction velocity of atrial muscle and the physiological factors such as turn back wavelength.[9] The electrophysiological remodeling induced by atrial fibrillation will make these physiological characteristics change to varying degrees. At present, there are three main methods: template matching , blind processing and primary frequency analysis.

Analysis based on PCA

Usually, BSS and PCA are used confusing. Although they use the same model, the objectives of the two are different. The purpose of BSS is to estimate the original source signal and do not impose

independence on the source signal; PCA makes the estimated signal as independent as possible. PCA uses higher order statistics in many cases, and BSS can solve the problem by using only two order statistics.[10] The use of the two order statistics needs to assume that the source signal has a certain time structure, while the higher order statistics require statistical independence between the source signals.

According to the output relationship of the PCA mixed network, each component of the output signal is a linear combination of the source signal. If the components of the Y are statistically independent, these components are bound to be a copy of the source signal (of course, the uncertainty of the amplitude and order). If an isolated component is a linear combination of multiple source signals, then this component could not and all other components are statistically independent, with all its output components are independent of each other. Therefore, each output component must be copy of a different source signal. When each component of Y is independent, the minimum value of mutual information is 0.

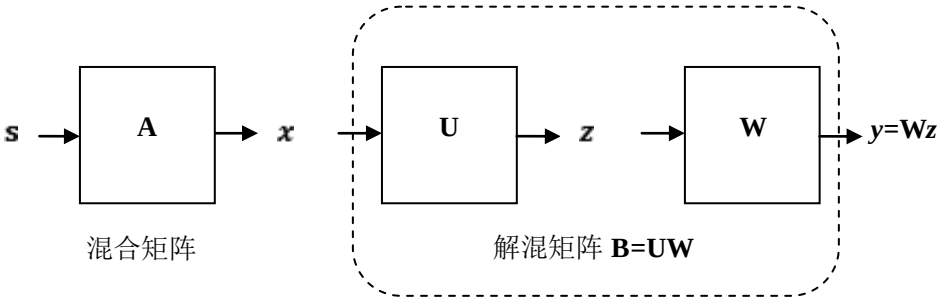

Figure 2. The mixed solution process

The independent output of each component can guarantee the successful separation of each source signal, so PCA can be solved by mutual information minimization.
The functions of the negative entropy [11] are

$$G_1(u) = \frac{1}{a}\log\left(\cos h(au)\right)$$

$$G_2(u) = \frac{1}{4}u^4 \tag{1}$$

The mutual information of signals after separation is shown in equation 1. By using correlation theory, we can see that when a constant is used, if we expand the formula 2 into a series of high-order statistics.

$$I\left(\mathrm{y}\right) \approx C - \frac{1}{48}\sum_{i=1}^{n}\left\{4k_{3i}^2 + k_{4i}^2 + 7k_{3i}^4 - 6k_{iii}^2 k_{4i}\right\}$$

(2)

In the formula, C is a constant; and the three and four order cumulant measurements are expressed respectively.
If the signal is symmetrical, that is. The formula (2) is rewritten as

$$I(y) \approx C - \frac{1}{48}\sum_{i=1}^{n} k_{iii}{}^2 \tag{3}$$

When the maximum mutual information is minimum, the minimum of mutual information is reduced to the maximum of the four order. The separation of the independent component is realized by the calculation of the four order cumulant, thus the non Gauss property of the output is the strongest.

Conclusion

In this paper, room wave and ventricular wave can be considered as statistically independent. Both atrial wave and ventricular wave have non Gauss property. The body surface observed ECG can be regarded as an instantaneous linear combination of room wave and room wave. The unknown mixing coefficient depends on the placement of electrodes and the conduction rate of body tissues. The body surface electrocardiogram of patients with atrial fibrillation can satisfy the above conditions, so we can reconstruct atrial fibrillation signal from all lead by establishing a reasonable linear model.

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