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SYSTEMS-LEVEL QUALITY IMPROVEMENT

Automatic Detection Algorithm for Atrial Fibrillation Based on Atrial Fibrillation and Suspicious Boundary of Sinus Rhythm

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Abstract
With the approaching of the aging of the population in China, the risk of heart disease increases with age. Atrial fibrillation as a common heart disease has seriously affected people's lives and health. A study of atrial fibrillation, dynamic electrocardiogram is usually used to analyze atrial fibrillation. But the accuracy of this analytical method may be artificially disturbed, which causes errors in the process of data analysis. Therefore, the computation analysis is carried by combining the automatic detection algorithm. By using the calculation of computer algorithm, the accuracy of data analysis of dynamic electrocardiogram can be increased. And through the test of automatic detection algorithm, the effectiveness of the algorithm can be found.

Keywords Dynamic electrocardiogram · Atrial fibrillation · Automatic detection algorithm

Introduction

Because of the large population base, China gradually began to enter the aging society. The incidence of heart disease is gradually increasing, it has become one of the biggest killers affecting human life safety (Amhaz Ret al2016) [1]. Heart disease is a general term for a myocardial disease, among the atrial fibrillation is a heart disease, which has a high incidence of disease (Fakiris Eet al2016) [2]. The study of this article is passed through the analysis of dynamic electrocardiogram information, and then the automatic detection algorithm is combined to calculate, analyze the situation through this calculation. The dynamic electrocardiogram data of patients with atrial fibrillation are analyzed, the accuracy of disease monitoring can be improved. It can not only provide patients with more accurate detection reports, but also bring accurate detection results to doctors' treatment. So as to achieve the purpose of improving the cure rate of patients, thereby ensuring the safety of patients' lives (Pratama P Set al2016) [3].

The research of this paper is to deal with the data of dynamic electrocardiogram, and to use automatic detection algorithm in the way of processing. Therefore, a detailed understanding of the calculation form and calculation procedure of the automatic detection algorithm should be firstly made. Then the computation of the automatic detection algorithm is combined with the data calculation of the dynamic electrocardiogram. After studying the above contents, the calculation formula of automatic detection algorithm and computer computational model can be analyzed, by studying the calculation formula, a new form of computer calculation is established, to achieve stronger computational and analytical capabilities for dynamic electrocardiogram data (Oliveira S Pet al2017) [4]. At the end of the paper, the calculation of automatic detection algorithm is also tested, by our test; it has been proved that powerful computing power of the algorithm. Through our computing and research of this article, the data analysis ability of dynamic electrocardiogram and the accuracy of data analysis can be effectively improved.

State of the art

Internationally, the study of atrial fibrillation based on suspected atrial fibrillation and sinus rhythm is very early, in the last century; many scholars have analyzed and studied it. Foreign medicine is relatively developed, all kinds of equipment development and upgrading of technology are very fast

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(Gupta Aet al2016) [5]. In particular, the research of automatic detection algorithm has improved our research calculation to a new level. Automatic detection algorithm is a new computer algorithm rising in the 90s of last century. This kind of computer algorithm has the inherent advantage to the dynamic information computation research, so people have a wide range of medical applications (Jeppesen Jet al2017) [6]. For dynamic electrocardiogram information calculation is only one aspect (Forouzanfar Met al2018) [7].

Analysis of dynamic electrocardiogram atrial fibrillation in suspected atrial fibrillation and sinus rhythm in China, which is mainly through studying abroad and combining with the development of Chinese physical fitness (Neshige Ret al2016) [8]. The study of atrial fibrillation is also in depth at home. In addition, the introduction of automatic detection algorithm improves the processing ability of dynamic data (Ghaffarian Set al 2016) [9]. The application of automatic detection algorithm in the analysis of dynamic electrocardiogram data has been gradually developed in China. This computer algorithm plays an important role in medicine, and provides some help for the development of medicine (Peters Met al2016) [10].

Methodology

Research progress on automatic detection of atrial fibrillation

In atrial fibrillation, the activity of atrial activity in the electrocardiogram is characterized by the disappearance of P waves, and the generation of continuous irregular f waves. As a result, the analysis of atrial activity is the analysis of P wave or f wave, summing up the related research of the predecessors; it can be divided into two methods: time domain method and frequency domain method.

The time domain method mainly analyzes the characteristics of P wave, for example P wave interval (P wave duration), P wave dispersion (P wave dispersion), P wave variability and so on(P wave variation). The following picture is the average electrocardiogram of the P wave signal (Figs. 1 and 2).

The P wave average method is commonly used in P wave feature point detection technology, the principle is based on the P wave or the R wave as the reference point, in the fixed time window, P wave pattern matching is used to build superposition template. Then the P wave is superimposed on average in the template, when the average noise level reaches a threshold value, the termination is superimposed, the average electrocardiogram of P wave signal is finally obtained. Based on the average electrocardiogram of P wave signal, the starting point and terminal location of P wave can be obtained, and the P wave interval can be also obtained. The accuracy comparison table of atrial fibrillation algorithm based on P wave interval is shown in Table 1 below.

But through our analysis of previous research results is found, at present, some scholars begin to use automatic detection algorithm to calculate and analyze the dynamic electrocardiogram of atrial fibrillation. But due to the restriction of technology and other factors, the computational accuracy is not very good or even difficult to use. In medical research, if the computational accuracy of the algorithm is not enough, it may directly affect the treatment of patients and may endanger the safety of patients. So our analysis of medical data has to be extremely accurate. The research and analysis of this paper will summarize the shortcomings of previous studies, the calculation steps and calculation processes of the algorithm are optimized, which is to improve the efficiency and accuracy of calculation. By analyzing the shortcomings of previous studies, the key points and key technologies of some optimization research are found. Among the optimization and improvement of histogram analysis methods and the analysis of other data calculation methods are particularly important. It should be known that the diagnostic technology of atrial fibrillation through dynamic electrocardiogram has been very mature. The calculation accuracy and efficiency of the algorithm can be improved only with the calculation steps of automatic detection algorithm and the optimization of the calculation form.

By analyzing the insufficient calculation of automatic detection algorithm based on RR period, it should be known that, the reason why the calculation accuracy is not high is that the algorithm is difficult to exclude interference and noise points; this is due to the lack of data analysis and processing

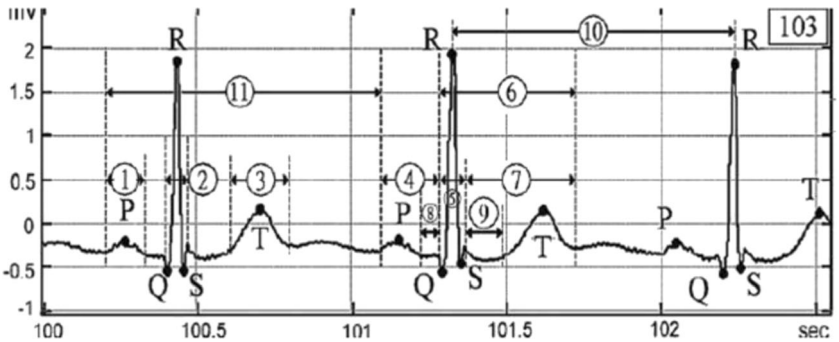

Fig. 1 P wave signal average electrocardiogram

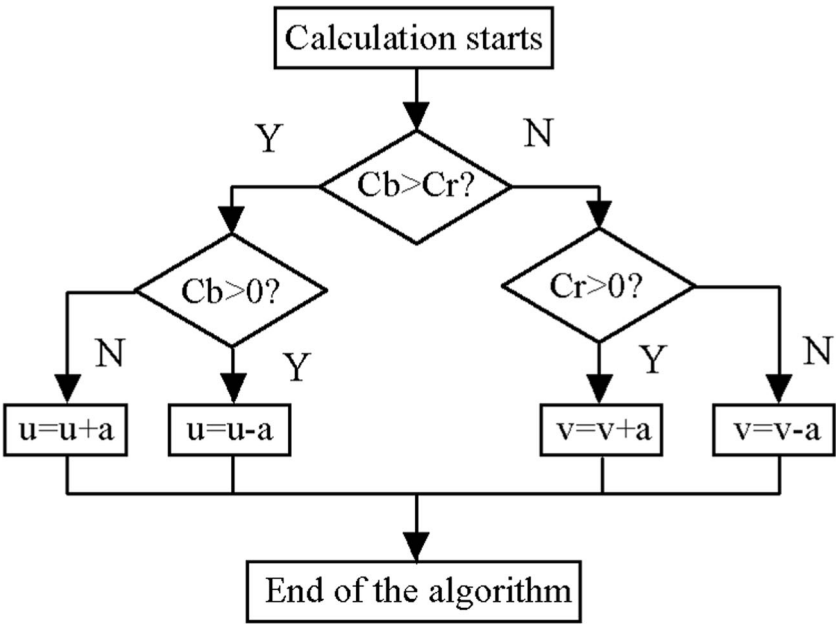

Fig. 2 Information flow chart of automatic detection algorithm

ability of the algorithm. The defect of automatic detection algorithm can be compensated by the computation of other computer algorithms. On the basis of previous studies, an automatic detection algorithm for atrial fibrillation combined with P wave analysis is proposed. In this way, the overall calculation accuracy of the algorithm has been greatly improved. In addition, this also helps to improve the efficiency of computing. This point will be analyzed in detail when the formula of the algorithm is studied. In this paper, the atrial fibrillation algorithm based on RR interval and the algorithm combined with P wave analysis are used to verify the clinical data respectively, automatic detection algorithm for atrial fibrillation combined with P wave analysis and clinical validation and application of automatic detection algorithm for atrial fibrillation, objective to provide an objective basis for further clinical application of clinical dynamic ECG analysis system.

For the automatic detection algorithm of atrial fibrillation, the key points of our optimization research and the shortage of previous research through the analysis of the progress of our predecessors are obtained by us. The combination of computer algorithms and medical technology is not an easy task, not only to ensure the efficiency of the algorithm, but also to ensure that the accuracy of the algorithm for medical data can meet the requirements. The research of this paper has found that the calculation of the algorithm is insufficient; our next phase of research will make up for these deficiencies.

Research on automatic detection of atrial fibrillation based on RR interval

In the above analysis, the progress of automatic detection algorithms for atrial fibrillation is known both at home and abroad, and found a lack of it. In the following analysis, the new technology will be used to study the automatic detection algorithm of atrial fibrillation based on RR interval.

In fact, it is only for the difficulty of testing, the detection difficulty during RR is actually much lower than that of P wave detection. But the accuracy of the test is much higher. Therefore, this paper detects and calculates the RR period based on the original research, this can effectively improve the accuracy of the study. But in fact in practical medical research, accurate localization of atrial fibrillation and sinus rhythm boundary can improve accuracy of patient detection. But at present, there is no safe way to combine the two studies. Therefore, the focus of this paper is to find this way to further improve the accuracy of calculation. But this method must be studied, which is combining with automatic detection algorithm. Because the automatic detection algorithm is the root of this paper, this cannot be abandoned. Therefore, this chapter will briefly introduce the detection algorithm of QRS wave in dynamic electrocardiogram to obtain R-R interval, and to provide data support for later atrial fibrillation algorithm; and then, a new method which can accurately locate the suspected boundary of atrial fibrillation and sinus rhythm is proposed, and related pretreatment is carried out; at the same time, objective to study the evaluation method of RR interval distribution in atrial fibrillation; finally, an automatic detection algorithm for atrial fibrillation based on K-S test is implemented at the suspected boundary between atrial fibrillation and sinus rhythm.

Next, the computing environment and calculation formula of the automatic detection algorithm are described. The electrocardiogram signals are processed by 5~11 Hz band pass filtering, differential, integral, squared and so on the preconditioning process, in order to eliminate common noise such as power frequency interference, electromyography interference,

Table 1 Comparison of Atrial Fibrillation Algorithm Accuracy Based on P wave Period

algorithm	Method description	SE(%)	SP(%)	PPV(%)
Steinberg J.S. et al.	P interval, 140 ms	77	55	37
Buxton A.E. et al.	P wave period, I1 0 ms	83	43	38
Stafford P J. et al	P interval, 141 ms	73	48	34
Fukunami M. et al.	P interval, 120 ms	95	48	70
Dilaveris P.E. et al.	Maximum P interval, 110 ms	88	72	84
Aytemir K. et al.	Maximum P interval, 106 ms	73	75	79
Andrikopoulos G.K. et al.	Maximum P interval, 110 ms	88	72	–

respiratory interference and motion artifact and so on, and further highlight the QRS wave signal. Low pass filter: the transfer function is as follows:

$$H(z) = \frac{1}{32}\left(\frac{1-z^{-6}}{1-z^{-1}}\right)^2 \tag{1}$$

The difference equation corresponding to the transfer function is that:

$$y(n) = 2y(n-1)-y(n-2) + \frac{1}{32}[x(n) + 2x(n-6) + x(n-12)] \tag{2}$$

When the sampling rate is 200 Hz, the low pass cut-off frequency is 11 Hz, and there is a delay of 25 ms. High pass filter: composed of all pass filter and low pass filter, the transfer function can be expressed as:

$$H_{hp} = z^{-16}-\frac{1}{32}\left(\frac{1-z^{-32}}{1-z^{-1}}\right) \tag{3}$$

The difference equation corresponding to the transfer function is that:

$$y(n) = x(n-16)-\frac{1}{32}[y(n-1) + x(n)-x(n-32)] \tag{4}$$

When the sampling rate is 200 Hz, the cut-off frequency of the high pass filter is SHz and the 80 ms delay is also achieved. Five point difference operation: the QRS wave is enhanced; the T and P waves are suppressed. The formula is as follows:

$$y(n) = \frac{1}{8}[2x(n) + x(n-1)-x(n-2)-x(n-3)-2x(n-4)] \tag{5}$$

The sum of squares and integrals operation:

$$y(n) = \frac{1}{N}[x(n-[N-1]) + x(n-[N-2]) + \cdots + x(n)] \tag{6}$$

In the above text, the calculation process and calculation steps of the algorithm have been studied. In addition, according to the optimization key points above, the calculation have been optimized, finally getting the formula of the automatic detection algorithm. Through this calculation form, the information of the dynamic electrocardiogram can be accurately calculated. In order to show the calculation process of the algorithm more clearly, the following figure is shown.

According to our form of calculation, the data monitoring rules of the algorithm need to be analyzed, first of all, the built up wave crest should be ignored, which always exists in the form of noise data. If there is a wave peak, it needs baseline drift, there are various forms of data analysis of the algorithm, and analysis needs to be separated according to the specific data. The optimization of the computational form of the algorithm has been completed, next, begin to test and analyze the algorithm.

Result analysis and discussion

In the above text, the calculation process and calculation steps of the automatic detection algorithm have been analyzed and researched, and according to the lack of previous research, the algorithm has been moderately optimized. However, the use of algorithm still needs to be tested and analyzed. The data acquisition parameters are as follows, (1) Number of channels: three leads, namely V1, V5, aVF lead; (2) sampling frequency: 100 Hz; (3) sampling accuracy: 8 bito.

According to the parameters in the above design, the test calculation research can be carried out, the optimization of algorithm is also studied and analyzed by the former scholars, and therefore, the experiment tests are carried out by combining with other optimization forms. The test results are studied using the following Table 2.

It can be seen that the data in the table above are analyzed and studied, compared with the experiments of the other four control groups. The optimized automatic detection algorithm has better computing performance, and the dynamic electrocardiogram data can be accurately analyzed and sorted out, although the accuracy of the calculation is not accurate. From the calculated data, it can see that the accuracy of the

Table 2 Comparison of the calculation results of the optimized forms of several algorithms

Group Name		K-S test, $P = 0.3$	Histogram improvement, P = 0.3	Standard deviation improvement, P = 0.3	NARsR improvements, P = 0.3	This article improves, P = 0.3
Paroxysmal atrial fibrillation group	SE(%)	94	94	93	93	99
	SP(%)	92	96	92	96	98
Full Atrial Fibrillation Group	SE(%)	99	98	98	99	98
	SP(%)	–	–	–	–	–
Abnormal sinus rhythm group	SE(%)	–	–	–	–	–
	SP(%)	76	83	77	84	98
Normal sinus rhythm group	SE(%)	–	–	–	–	–
	SP(%)	98	99	98	99	99

calculation is much higher than that of the other four methods. The percentage of calculation results is over 98%, which is much better than that of other algorithms. Especially in the calculation of normal atrial fibrillation group and the normal sinus rhythm group, the accuracy of calculation is prominent. In addition, the calculation results for the other two computing groups are also very high, reaching 98% of the total. This set of tests can be determined by us, through the study of this paper, the computational performance of the automatic detection algorithm has an unprecedented improvement, which can be applied to paroxysmal atrial fibrillation, whole atrial fibrillation, abnormal rhythm and normal sinus rhythm, and can achieve a very good calculation effect. Through this test, it is proved that the automatic detection algorithm optimized in this paper can be used for the calculation of dynamic electrocardiogram data in medicine. But there is no accurate control over the accuracy of the algorithm and the computational efficiency of the algorithm. The practicability of automatic detection algorithm can be proved by the test of computational efficiency and computational accuracy. Next, the computational efficiency of the algorithm and the accuracy of the algorithm are tested separately.

For the calculation of the efficiency of the algorithm, the comparison of the five algorithms is still adopted, but the efficiency of the whole atrial fibrillation group and the normal sinus rhythm group is tested. For computational efficiency, it

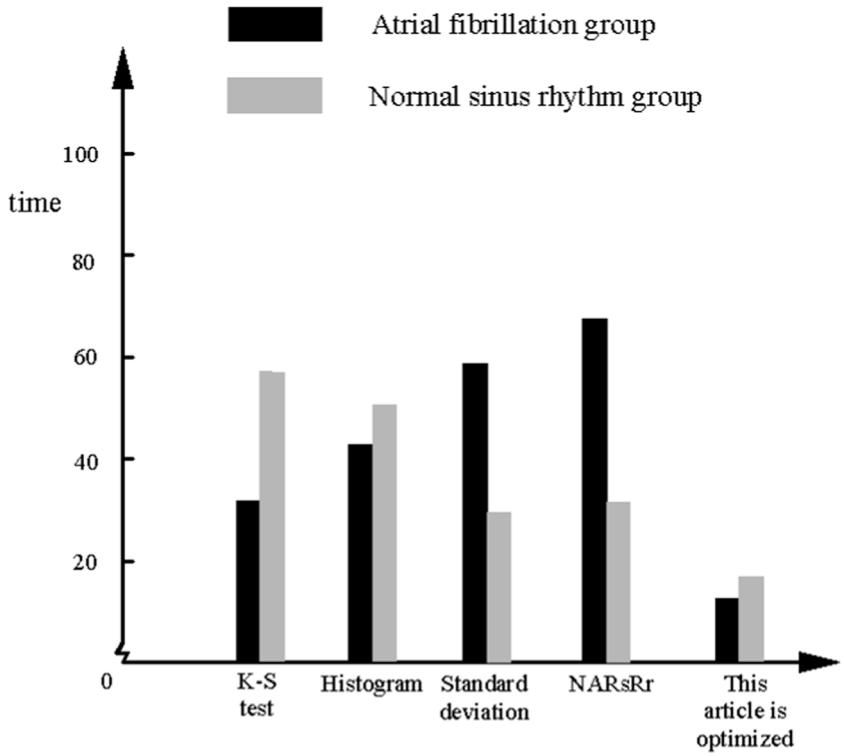

Fig. 3 Comparison of the calculation time of the five algorithms

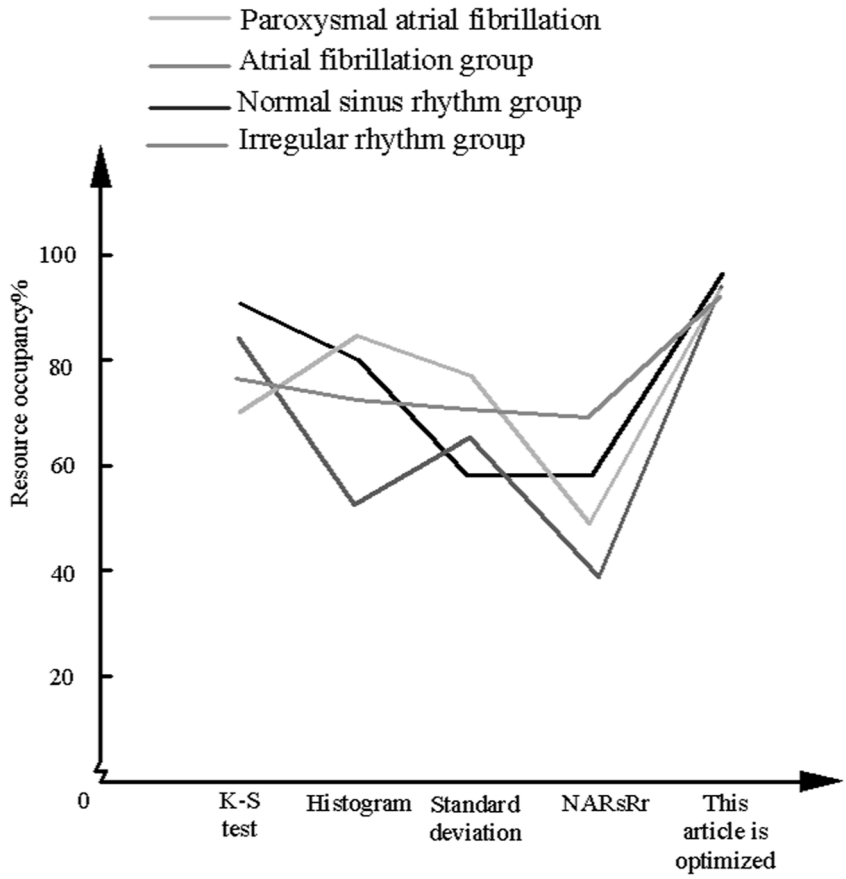

Fig. 4 Comparison of the accuracy of the five algorithms in different test items

is determined by the detection of computation time, because the computation efficiency is inversely proportional to the computation time, the longer the computation time, the lower the computation efficiency. Next, the results of the test are analyzed by using fig. 3 below.

Testing the above calculation time can be found, in the two test items, the optimized algorithm in this paper has the shortest computation time and the highest computation efficiency. In the two different test items, the computation time of the automatic detection algorithm used in this paper does not exceed 10 s. This also shows that the automatic detection algorithm used has a comfortable sense of use when it is actually applied.

In addition, the accuracy of the algorithm is also tested by us, the accuracy of the algorithm is tested by all the test groups and all the testing algorithms, and then the comparison of the accuracy of the algorithm is shown in Fig. 4 below.

The analysis of the data above can be seen that, the accuracy of the automatic detection algorithm used has been stable over 95%, far superior to the other four algorithms. The practicability and feasibility of the algorithm are proved by the above tests. The calculation results are good, strong practicality.

Conclusion

With the increase of population aging in China, the incidence of heart disease such as atrial fibrillation is increasing. In order to cope with the increasing trend of patients with atrial fibrillation, by using the automatic detection algorithm, the data of the ambulatory electrocardiogram is analyzed to improve the diagnostic speed and accuracy. In addition, through the optimization research of the algorithm, the computational performance of the automatic detection algorithm is greatly improved. In this paper, through the test of the algorithm, the optimized automatic detection algorithm can calculate the atrial fibrillation dynamic electrocardiogram data under various circumstances, and its calculation results can achieve our expected goal. In addition, the computational efficiency and computational accuracy of the optimized automatic detection algorithm are also tested. The computational efficiency of the algorithm is much better than that of the other four algorithms, and the maximum computational efficiency gap is even 5 times. The success of our optimization can be recognized. In addition, the calculation accuracy test proves that the calculation accuracy of the algorithm is more than 95% in different situations. The algorithm has very strong practicability.

Compliance with ethical standards

Conflict of interest There is no conflict of interest in this article.

Human participants and animal studies This article does not cover human participants and/or animal studies.

All the authors of this article are aware of the content.

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