The Algorithm of the Quick Fitting LADT

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Summary
The paper proposes a new method which controls line based on improving radial fitting. Experiments on selected records from the MIT-BIH arrhythmia database revealed that improved algorithm doesn't only increase computation quantity, but also improve approximating quality, strengthen Real-time application of LADT.

Key words:
ECG data compression , LADT algorithm , MIT-BIH arrhythmia database

1. Introduction

There is more and more applicative and continuous progress for LADT ECG data compression method in recent year. A lot of algorithms can be proposed from threshold、adaptive threshold compression algorithm to Zhao Yong and so on [1].Li gang and so on [2] [3] who proposed a fast realization of the LADT ECG data compression method. The new methods from approximating ECG by radial to fitting ECG by linear make the LADT ECG data compression method advance which means they satisfy the real-time requirements, a high compression ration and assure coming back after compression and don't produce distortion.

In the new method of the approximation ECG by radial, we found in the instance when the slope of the segment is very big, such as at the R wave period, the threshold could be very big too. Especially, when the ECG signal changes from the R wave to the base-line, as the slope of the segment approximation the R wave is very big, the segment will cross the ECG signal and only a few points can satisfy the precision, thus the saw-tooth like approximation appears. The reason is that the endpoints of the segment can't be determined properly.

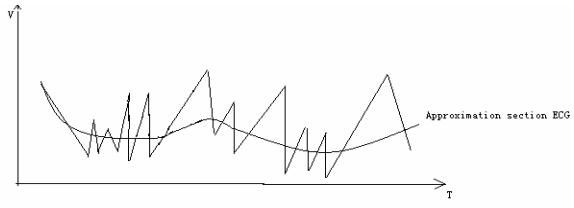

Fig 1 Saw tooth like approximation

In order to amend this disadvantage, Feng Jun [6] fixed the endpoints on the ECG waves and performed the new fast LADT algorithm and got the features of the ECG.

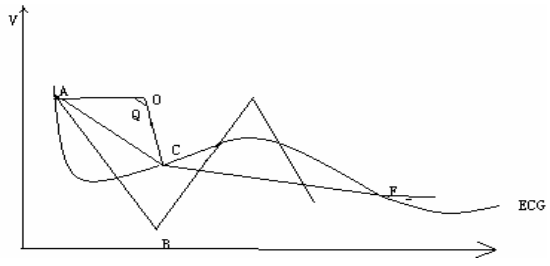

Fig2 Decision of the endpoints

But it is found it can make the fitting linear big distortion when the length of AB、AC is longer in the above amending method. We know it can record a few key points and can describe the ECG in the LADT

compression method. When the key points of AB、AC aren't fitness ,it can cause very big error.

The length of the fitting linear AB、AC can't be controlled very much for this disadvantage. The paper proposed another algorithm for the linear AC based on the disadvantage .In order to eliminate accuracy error because of the changing curve. The distortion is smaller, and the approximation quality can be improved.

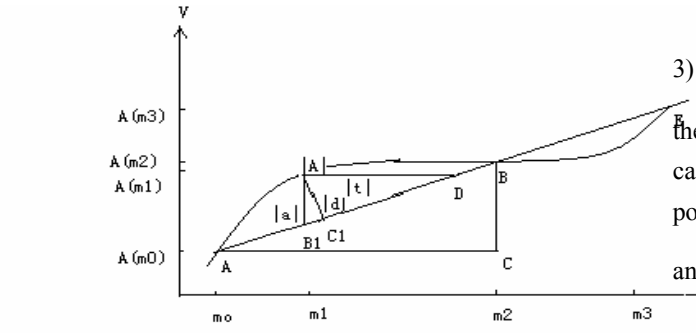

Fig3 Fast realization of LADT

From the figure 3, it is calculated by the fixed step m_0 which is given firstly based on the original define. It is very important to improve the real-time of the algorithm through finding the best step. But it is impossible to find the best original step.

In the fast LADT method, the radius is adopted to fit the curve .So it doesn't set up the question of the best original step. The figure 3, the original approximation step m_o which is a small-value is fixed .the curve AA'BE. It is presumed the length of AB is m_0, there is a radius from A as the start point to B, it is not only considered whether the points between AB correspond to the precision but also check the corresponded accuracy point after B.

The algorithm is as follows:

1） Make sure the fitting accuracy ε and a more smaller approximation step m_0, let $m_i = m_0$, m_i is the fitting length of ith fitting line.

2） By the principle of LADT, the slope is calculated about the fitting linear.

$$k = \frac{|A(m_2) - A(m_0)|}{|m_2 - m_0|} = \frac{|a|}{|t|} \qquad (1)$$

And the error accuracy is calculated

$$a_{\max} = \varepsilon(1 + k_i)^{1/2}$$

3) Assuming the start point coordinate $A(m_0, A(m_o))$, the first point after A is beginning with fitting, and calculated the amplitude difference between every data points and the corresponding point of approximate linear, and check the relation with $a_{\max}$.

If $|a_j| \le a_{\max}$, the point met the fitting condition and calculate the next $a_j + 1$ repeat the step until e, which makes $|a_j| \ge a_{\max}$. $(j = 1,2,\cdots,m_i)$.

When $m < m_i$, let $m_i = m$, do the step 4.

When j= m_i, do the step 5, the radial is adapted to fitting curve.

4.If $|a_e| > a_{\max}$, eth point is the endpoint of the fitting linear. Let $m_i = e - 1$, it is the length of the fitting linear.

Make sure the abscissa of the endpoint is $m_0 + e - 1$, and then look for the point on the ECG signals which have the same abscissa, and its coordinate is $(m_0 + e - 1, A(m_0 + e - 1))$, and it is the start point

ad the next fitting linear. Do the step 5.

5.Check the total length of the data.

If $m_0 + e > N$, the fitting is over, and we obtain the array M, record the length of every fitting linear, and the coordinate array of the endpoint of the fitting linear P.

2.2. Improvement about the fast realization of the fitting curve

The fast realization by curve exist the lack: the fitting length of ith fitting linear can't control effectively. The implement method makes the approximation curve distortion.

The aim is that makes use of the relation of angle at the centre to control m_i .Figure 2, AC as the chord, we can draw a circle by the chord of AC, and the radius of the arbitrary distance. The angle at the centre corresponding to the AC is $\angle \mathrm{AOC}=\Phi$. To obtain the best m_i, it needs to handle φ, and can solve the above question effectively to meet the aim of fitting in the $\triangle \mathrm{AOC}$,

$$\cos\Phi = \frac{OA^2 + OC^2 - AC^2}{2 \cdot OA \cdot OC} = \frac{2 \cdot OA^2 - AC^2}{2 \cdot OA^2}$$

$$AC = \sqrt{2 \cdot OA^2 (1 - \cos\Phi)}$$

When $\Phi \to 0$, A inclines to the overlap with C, that is to say the distance of AC inclines to zero, it is irrelevant with the radius OA. So we don't consider the radius in the process of looking for Φ.

The concrete change is that changes the fourth step with relation to the endpoints. The step as follows:

5'. If $|a_e| > a_{\max}$, eth is the endpoint of the fitting linear, and makes sure the abscissa of the endpoint is $m_0 + e - 1$, looking for the point of the same abscissa in the ECG curve, obtaining the coordinate is $(m_0 + e - 1, A(m_0 + e - 1))$. The linear between the eth point and the start point is looked as the chord, drawing the circle, and looking for whether the angle at the centre is inclined to zero. If this, this point is the start point as the next fitting linear, do the step 5. Otherwise, the point before eth point is the endpoint, repeat the step 4'.

3.Experiment and results

The fitting method is improved. Based on the original fast fitting and Feng Jun's improvement, it avoids the more distortion in the fast fitting, improving the quality of the fitting linear. By the detecting from the MIT-BIH arrhythmia database, the fitting linear difference is very obvious between QRS complex and base-line, between the slope and the length: the slope of the fitting linear is bigger for the QRS complex, at the same time its length is long compared with the base-line. Of course, because of the existence and controlling of the angle at the centre, it makes the slope change big or small some times in the process of the fast fitting. Although the changing case doesn't fix the fitting accuracy is more accurate.

The slope and length feature of the fitting linear are obtained by the fitting which describe the ECG. The data needed analyzing is compressed. At the same time the main feature of the ECG curve of the ECG curve is preserved, the difference is very small between the reconstruct wave and the original curve. Further more, the speed and efficiency is very good.

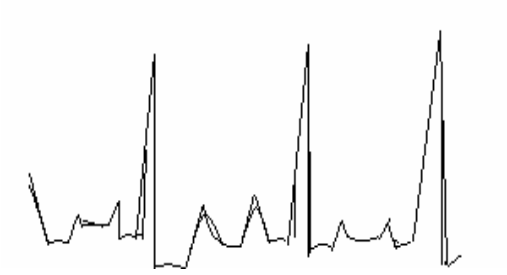

Fig 4 Realization of modified LADT

Figure 4 is the signal T105 and its fitting curve from 10 to 13 seconds from the MIT-BIH arrhythmia database. The original accuracy of the preset distance is $\sigma = 4$. The mean square error of the fitting result is 1.03% and 1.88%, respectively. The mean lengths are 85.46 and 84.25, the mean length of the data are 12.45 and 16.65 compared with the previous experiment. By the computation to the total data of the signal T105, the whole mean square error are 1.2% an 1.9%, the mean length are 85.10 and 83.5, respectively.

Table 1 Results of approximation with modified LADT

ECG data	The mean length of the linear	The mean length of the data	ECG data	The mean length of the linear	The mean length of the data
T100	56.1[6] 57.1	14.1[6] 10.2	T111	65.6[6] 66.9	14.7[6] 10.6
T101	57.6[6] 58.7	16.7[6] 12.0	T112	58.5[6] 59.6	12.0[6] 9.1
T102	52.6[6] 53.6	13.4[6] 9.9	T217	64.5[6] 65.7	20.0[6] 16.2
T105	83.5[6] 85.1	14.8[6] 10.1	T219	65.9[6] 67.2	16.6[6] 12.5
T106	67.7[6] 68.0	16.1[6] 11.9	T220	57.2[6] 58.3	16.8[6] 11.9
T108	47.7[6] 48.6	11.2[6] 9.6	T221	68.9[6] 69.7	15.3[6] 10.2

Note: in the table, the later data in every grid is obtained data based on improvement algorithm which is proposed in the paper.

From the table, the fitting quality has very big improvable from the improvement algorithm, and decrease the distortion. The fitting linear accurately reproduces ECG data, and presence the classification information of the ECG signals.

4.Conclusion and discuss

The paper proposed a new method that approaches the curve with the angle at the centre. The method assures that the degree of the angle at the centre is very small, and we don't consider the radius length, that the longer linear approaches the QRS complex. It avoids the big error, improves the fitting quality and decreases the distortion.

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