A NEW APPROACH TO DIGITAL PROCESSING OF ECG SIGNALS

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Abstract— Electrocardiogram (ECG) signals have become a promising means of achieving automatic detection of diseases using high-level processing algorithms. In this paper, a new wavelet delta-function (WDF) method has been proposed for the effective detection of pathological conditions from ECG signals. In this case, the ECG is converted into the sum of WDF with a coefficient of 0, 1 and -1. This made it possible to make changes in the diagnosis with higher accuracy than traditional methods.

Keywords— Electrocardiogram (ECG), diagnosis, Delta function, wavelet, coefficient, Gaussian function, PhysioNet, Challenge 2011 Test Set B, Myocardial infarction (MI).

Introduction

Myocardial infarction (MI), a type of ischemic disease, especially cardiovascular disease, is now one of the leading causes of disability in adults, accounting for 12-15% of all deaths. MI is more common in men between the ages of 40 and 60. In women, the disease is about one and a half to two times less common. The incidence of MI also increased between the ages of 30 and 39; Cases of MI in the 20-29 age group are also not uncommon. Thus, MI affects the most socially active part of the population.

According to the World Health Organization, 56% of all deaths are due to cardiovascular disease. In European countries, cardiovascular disease kills 4.3 million (48%) people a year.

In the treatment of patients with acute MI, the time factor is crucial for the prognosis of life and ability to work. Analysis of ECG signals using processing methods can significantly accelerate the initiation of medical care.

We analyze ECG signals using delta functions.

In this study, we use the Challenge 2011 Test Set B database [1], which is open from PhysioNet, to teach our model. The Challenge 2011 Test Set B database contains 488 ECG recordings, each lasting approximately 30 minutes and a sampling rate of 360 Hz. Each ECG record has twelve lines called I, II, III, aVL, aVR, aVF, V1, V2, V3, V4, V5, and V6. In this study, Challenge 2011 Test Set B was processed with 1000066 entries from the database.

As a delta function we get the following function.

$$\delta(x_i, x_j) = Ae^{\frac{-(x_i - x_j)^2}{2\sigma^2}} \quad (1)$$

where A is the amplitude, delta is the height of the function.

Let's get the ECG signal for the wavelet model in $x \in [0;1]$ seconds. To do this, we choose the delta function in formula (1). So we work with the function

$f(x_i) = EKG + y_0$ at $\delta(x_i, x_j) > 0$ in the interval $x_i, x_j \epsilon (-\infty; +\infty)$. The expected result is as follows:

$$f(x_i) = \sum k_j \delta_n (x_i, x_j) \qquad (2)$$

where a coefficient of $k_j = 0$ or $k_j = 1$.

The first step

We set $\delta_0(x_i, x_j)$ for each maximum function value $f(x_i)$.

So we fill the row with $\delta_n(x_i, x_j)$ delta functions.

The second step is to find the coefficients k_j.

Find the coefficients k_j that correspond to the sum of the function $f(x) = EKG + y_0$ and the delta function $\sum k_j \delta_n(x_i, x_j)$.

$$S = \sum_{i=0}^{n} \sum_{j=0}^{n} k_j A e^{\frac{-(x_i - x_j)^2}{2\sigma^2}} \qquad (3)$$

where: S is the sum of the delta functions.

The following verification is sufficient to find k_j.

$$|f(x_i) - S| \leq \varepsilon \quad (4)$$

where $e = 0.01$ is the limit value.

Then $k = 0$ if the condition in formula (4) is satisfied, otherwise $k = 1 \vee k = -1$ [3][4][2].

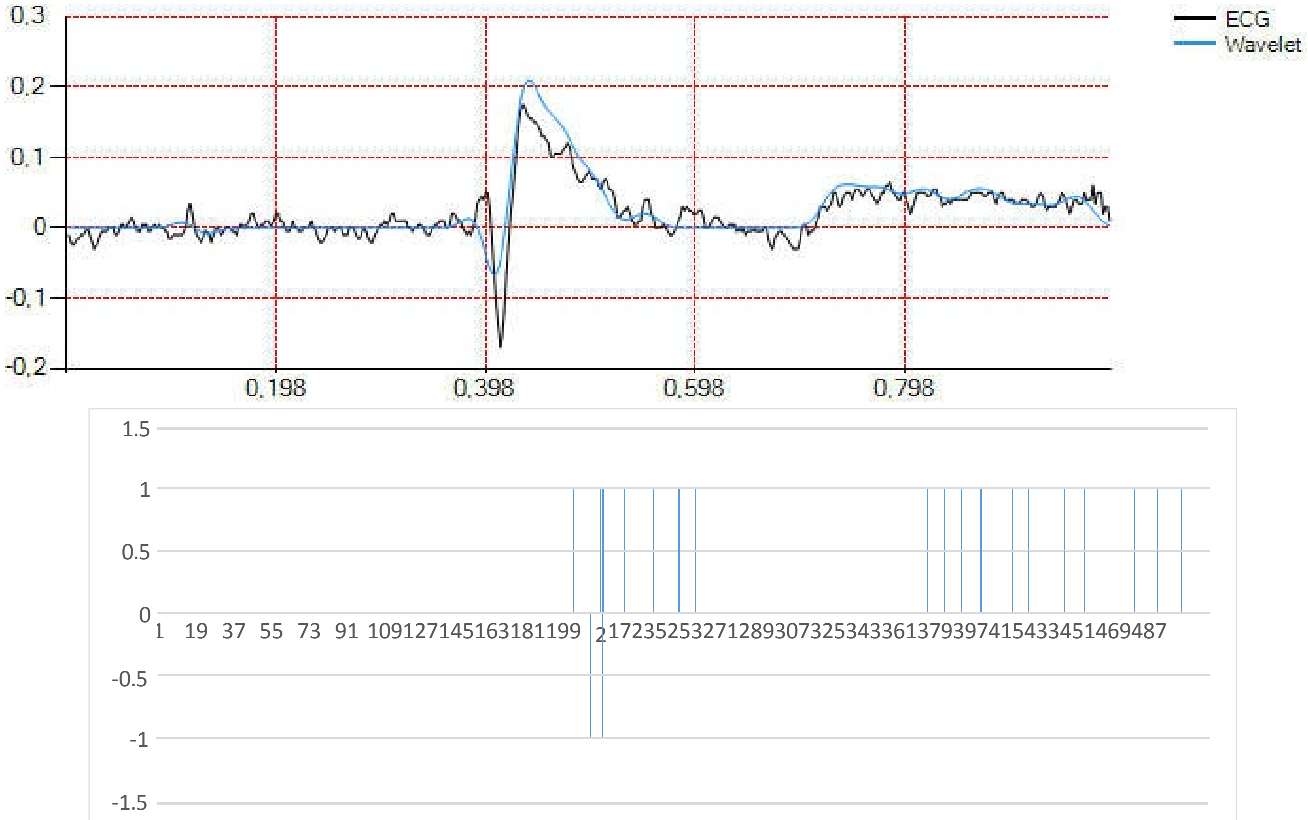

Figure1. ECG and wavelet graph and coefficient diagram

Thus, the known coefficient (0, 1, -1) of the ECG signal for the sample graph is expressed as the sum of the delta functions.

Table 1 Parameters for each type of ECG signal

EKG type	Y_0	ε	Time interval	A	σ
I	0.135	0.05	0.004	0.09	0.026
II	0.105	0.05	0.004	0.09	0.026
III	0.45	0.06	0.004	0.09	0.026
aVR	0.58	0.07	0.004	0.09	0.026
aVF	0.19	0.07	0.004	0.09	0.026
aVL	0.1	0.05	0.004	0.09	0.026
V1	0.575	0.08	0.004	0.09	0.026
V2	1.55	1.45	0.004	0.09	0.026
V3	0.71	0.23	0.004	0.09	0.026
V4	0.5	0.25	0.004	0.09	0.026
V5	0.44	0.15	0.004	0.09	0.026
V6	0.25	0.14	0.004	0.09	0.026

CONCLUSION

A new WDF method for ECG signals has been created. Using this method, the wavelet coefficients of the ECG signal were obtained in the form of 0, 1 and -1. With the help of this vector information, the level of detection of the difference between pathology and norm has been improved. A new method of processing ECG signals has been developed by converting graphical information into vectors. The new method created a barcode-like image. The patient was also offered a method of effective diagnosis using the obtained image.

With the help of coefficients, it was possible to more effectively see the invisible peaks in certain numbers on the ECG chart of diseases of the cardiovascular system. This allowed for early detection and accurate diagnosis of the disease. Our application settings are shown in Table 1.

References

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