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A New Anomaly Judgment Method of Vital Signs of Critical Ill Patients

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Abstract. As the fast-development of artificial intelligence and modern medical technology, the real-time monitor of vital signs of critical ill patients has become a hot topic in the field of medical research, and receives a wide range of attention. hereby present a new anomaly judgment method of vital signs of critical ill patients. This method first strengthen the vital signs signal, raise the intension vital signs signal, then use the low-pass filter to filter the high-frequency noise on the basis of differences in different frequency domain between vital signs signal and interfering noise, use the differences under statistical characteristics of normal condition and anomaly condition of vital signs signal of critical ill patients as standard, and then determine whether the vital signs signal of patients is normal or not. Finally, simulation experiments show that the algorithm is better than other traditional algorithms in accuracy.

1. Foreword

Nowadays, as the fast-development of artificial intelligence and modern medical technology, the real-time monitor of vital signs of critical ill patients has become a hot topic in the field of medical research, and receives a wide range of attention. How to determine the anomaly situation of vital signs of critical ill patients at any time precisely become a main problem in this hot issue waiting to be solved, also there appears many good methods to deal with it.

For example, method of monitoring alarm of vital signs of critical ill patients based on artificial neural network algorithm. This method complete the monitoring of vital signs of critical ill patients by selecting a group of pivotal variables used in clinical diagnosis from repeating variables. This method has a strong adaptation, but has the disadvantages of complex calculation, time-consuming and so on. Another usual example is the algorithm using the obvious fluctuation signals of vital signs to determine the anomaly value. Because the patients are at their critical stage, their fluctuations of signal of vital signs are small and hard to produce drastic changes, the differences of changes of signals has inevitable imperfection of unable to come up greater threshold due to the excessively weak of vital signs of critical ill patients in the process of network propagation of wireless sensors.

Aim at the appearance of above problems, hereby present a new anomaly judgment method of vital signs of critical ill patients. This method first strengthen the vital signs signal, raise the intension vital signs signal, then use the low-pass filter to filter the high-frequency noise on the basis of differences in different frequency domain between vital signs signal and interfering noise, use the differences under statistical characteristics of normal condition and anomaly condition of vital signs signal of critical ill patients as standard, and then determine whether the vital signs signal of patients is normal or not.

2. The principle of anomaly judgment of vital signs of patients

Suppose the critical ill patients' type number vital signs needed monitor is n, the distance between critical ill patients and alertor is l, the strength coefficient of vital signs signal of critical ill patients is d, the number i critical ill patient's initial value of vital signs is α_{ni}, the number k time collection of vital signs signal is α_{ki}, the serial number of the sensor on this patient is j, using formula below would be able to calculate the difference-value coefficient of vital signs signal of the number j sensor when the number k time signal gathering of the critical ill patients.

$$\varphi_{kj} = t_1 \frac{n \times l \times d \times \sqrt{\alpha_{ki} - \alpha_{ni}}}{j_2 + 1} - t_2 \frac{n \times l \times d \times \sqrt{\alpha_{ki} - \alpha_{ni}}}{j_2 + 1} \tag{1}$$

According to the formula above, it is able to determine the anomaly condition of vital signs of critical ill patients by acquiring the difference value of vital signs of critical ill patients.

Set the anomaly threshold of vital signs of number j sensor as r_j, suppose the value of φ_{kj} is bigger than the value of r_j, it can be determined that the vital signs of the patient is abnormal; if the value of φ_{kj} is smaller than r_j, then the vital signs of patient is in the normal range.

3. Method of optimizing

The vital signs signal of critical ill patients are always weak, so it may under the influence of external noise and thus exists the the problem of high deviation in the process of monitor. Therefore, a new anomaly judgment method of vital signs of critical ill patients are being raised.

3.1 Enhance the signal of vital signs

The enhancement algorithm of wavelet threshold could be used, the specific method as below:

Signals with noise through the wavelet transformation, the amplitude of wavelet coefficient generated from original signals is quite high and the quantity is small, however, the amplitude of wavelet coefficient generated from noise is quite small and the quantity is big. Therefore, select appropriate threshold value in different dimension, threshold process the wavelet coefficient, remove the wavelet coefficient which is smaller than threshold value and reserve the wavelet value which is bigger than threshold value, then process the reverse transformation of wavelet and obtain the optimizing estimation of the original signals. The steps are as follows:

(1) Select the appropriate wavelet function to process wavelet transformation of signal with noise, and obtain the wavelet coefficient at different dimensions. As for the N length signal with noise $f(t)$, suppose $N = 2^j$, use the high-speed algorithm of wavelet transformation to acquire the dimension coefficient $\{V_{L,k},\ k = 1, 2, ..., 2^L\}$ under low frequency $L(0 \le L < J)$ and wavelet coefficient $\{w_{j,k},\ j = L, L+1, ..., J-1. k = 1, 2, ..., 2^j\}$ under different resolution, the number of dimension coefficient and wavelet coefficient together is N.

(2) Proceed the non-linearity thresholding process of wavelet coefficient at different dimension. Take the general threshold $\lambda = \delta\sqrt{2\ln N}$, δ is the standard deviation of Gaussian white noise, N is the length of the signal with noise. As for each wavelet coefficient $w_{j,k}$, method of hard threshold can be used to proceed. Compare the absolute value $|w_{j,k}|$ of wavelet coefficient of signal with noise and the selected threshold λ, set the points which are smaller than threshold as zero; the points which are bigger than or equal with threshold remain constant.

(3) Use formula (2) and (3) to proceed wavelet reverse transformation and obtain the signal after denoising.

$$\varphi_h f(a,b) = \frac{l}{\sqrt{C_h}} \int_R f(x) \bar{h}\left(a\left(x - \frac{b}{a}\right)\right) dx \tag{2}$$

$$f(x) = \frac{1}{\sqrt{C_h}} \iint_{R'>R} \varphi_h f(a,b) h(a(x - \frac{b}{a}))\,\mathrm{dadb} \tag{3}$$

$\frac{b}{a}$ is the shift factor, when $|a|$ is largen, $|\frac{b}{a}|$ is lessen, vice versa.

3.2 The judgment of anomaly value of vital signs

In the process of acquiring the signal of vital signs of critical ill patients, use the difference between signals of vital signs extracted from the first round enhanced-denoising and interfering noise at different frequency domain, use the low-pass filter to proceed second filter at high frequency interference component, then use the differences of statistical characteristic between normal condition and abnormal condition of critical ill patients as standard to determine if it is normal or not. The specific procedure as below:

First, use formula (4) to acquire the differences at different frequency domain between signal of vital signs of critical ill patients and interfering noise

$$S(t)=\sum_{k=-\infty}^{\infty}\sum_{l=-\infty}^{\infty}J_k(\frac{4\pi m_1}{\lambda})J_l(\frac{4\pi m_2}{\lambda})e \quad (4)$$

The process of optimizing monitor alarm of vital signs of critical ill patients, the vital signs of critical ill patients is quite weak and will be interfered by all kinds of external noises, therefore, setting low-pass filter should according to the features of frequency domain of vital signs of critical ill patients itself and filteringthe high-frequency interfering component.

In the process of The process of monitor alarm of vital signs of critical ill patients, use the differences under statistical characteristic of conditions (normal and abnormal) of signals of vital signs of critical ill patients as standard. Set $D(X)$ as the variance of variable X of signal of vital signs of critical ill patients, it can demonstrate the value of the X and the degree of deviation of signal $E(X)$ of vital signs of critical ill patients under normal condition. The acquired value $D(X)$ is small, then the value range of X near $E(X)$, otherwise, if the acquired value of $D(X)$ is big, then the value range of X is sporatic, this moment can be demonstrated as the condition of signal of vital signs of critical ill patients is abnormal and required given an alarm.

4. Simulation result

Because of the weaknes of signal of vital signs of critical ill patients, it is possible that bigger threshold alarm cannot happen and lead to the reduction of precision of real-time monitor of critical ill patients. Therefore, raising a new method of anomaly judgment of vital signs of critical ill patients, first, enhance the life signal, raise the strength of signal of vital signs, then determine if the signal of vital signs are noemal or not. In order to prove the effectiveness of this algorithm, a experiment needs to be done.

Experiment 1)

Under condition of different sample numbers, use the algorithm of apparent fluctuation of vital signs, genetic algorithm and newly raised algorithm to proceed the experiments of extraction of signal of vital signs, compare the precision of signal of vital signs extracted from critical ill patients using different algorithm, the results are as in the Table 1.

As is shown in Table 1, the new algorithm is better than other two algorithm in the aspect of precision extracting the the signal of vital signs of critical ill patients, this is mainly because the new algorithm first enhance the signal,, raise the strength of signal of vital signs, extract signal of vital signs of critical ill patients accordingly, ensure the precision of new algorithm.

Table1 comparison of precision of different algorithm

Sample quantity	Wave algorithm	genetic algorithm	new algorithm
15	0.73	0.85	0.95
25	0.76	0.84	0.96
36	0.75	0.85	0.97
58	0.78	0.85	0.97
120	078	085	0.96

Experiment 2)

Under condition of different sample numbers, use the algorithm of fluctuation, genetic algorithm and improved algorithm to proceed the experiments of monitoring of vital signs of critical ill patients, compare the false alarm rate monitored by different algorithm.

As shown in Table 2, the alarm rate of using new algorithm to proceed monitor alarm experiment of vital signs of critical ill patiemts is lower than the other two algorithms, this is because the new algorithm use the differences in different frequency domain extracted from signal of vital signs of critical ill patients and interfering noise, use low-pass filter to filter high-frequency interfering component, use the differences of statistical characteristics under normal and abnormal conditions of signal of vital signs of critical ill patients as standard, then determine if the signal of vital signs of critical ill patiemts is normal or not, precisely achieve the monitoring alarm of signals of vital signs of critical ill patients.

Table 2 comparison of false alarm rate of different algorithm

Sample quantity	Wave algorithm	genetic algorithm	new algorithm
15	0.005	0.002	0
25	0.005	0.002	0
36	0.005	0.004	0.0001
58	0.008	0.004	0.0001
120	0.005	0.003	0

Experiment 3)

Use the algorithm of fluctuation, genetic algorithm and new algorithm to proceed the experiment of monitoring of vital signs of critical ill patients, compare the noise immunity of different algorithm experiments, the the comparison results are as below in table 3.

Table 3 comparison of noise immunity of different algorithm

Sample quantity	Wave algorithm	genetic algorithm	new algorithm
15	0.59	0.63	0.85
25	0.53	0.64	0.88
38	0.54	0.64	0.87
58	0.53	0.63	0.89
120	0.52	0.64	0.87

As shown in table 3, use the new algorithm to monitor the noise immunity of experiment of vital signs of critical ill patients has certain asvantages compared with other algorithms. Because, first, the new algorithm has been proceed the first round filter as the enhancement of signal of vital signs of critical ill patients, then set the low-pass filter according to the characteristics of frequency domain of signal of vital signs of critical ill patients themselves and filter the high-frequency interfering component, effectively guranteed the noise immunity of improved algorithm.

5. Conclusion

This paper propose a new method of anomaly judgment of vital signs of critical ill patients, experimental results show that this method largely raise the precision of anomaly judgment of vital signs of critical ill patients.

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