IRSTI 50.03.05

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Use of machine learning for early pre-clinical diagnostics of heart diseases

Abstract. The main cause of death in different countries are heart diseases. Therefore, the problem of early preclinical diagnosis of these diseases at the origin is acute. ECG analysis is widely used to diagnose many cardiac diseases. Since the majority of clinically useful information in the ECG is found in the intervals and amplitudes determined by its significant points (characteristic peaks and wave boundaries), the development of accurate and reliable methods for automatic ECG delineation is a matter of great importance, especially for the analysis of long records.

This article presents an intelligent system for the interpretation of electrocardiographic signals of cardiac valves based on the wavelet transform method. The model of the neural network of wavelet packets developed by us is used. The productivity of the developed system was estimated in 2000 samples. The test results showed that this system was effective when using wavelet transform methods. The correct rate of classification was about 91 percent for abnormal and normal subjects.

The aim of the study is to develop a neural network based on the wavelet transform method for early preclinical diagnosis of diseases, and paroxysmal atrial fibrillation of the heart.

At present, the problem of processing fuzzy data, short high-frequency low-amplitude signals is difficult to solve. Since, for example, if the ECG is visually monitored, the probability of obtaining a human error is high, every 10-result is interpreted with an error. In this connection, it became necessary to search for new methods for predicting signal propagation in various directions of science.

The problems of extracting information from the electrophysiological signal that can not be obtained by visual analysis of the record, as well as the problems of automation of traditional algorithms of medical analysis are relevant in connection with the lack of research in this field [1].

Key words: machine learning, neural networks, electrocardiogram, wavelet transformation.

Introduction

An artificial neural network is a mathematical model, as well as its software or hardware implementation, built on the principle of the organization and functioning of biological neural networks – nerve cell networks of a living organism. This concept arose when studying the processes occurring in the brain, and when trying to simulate these processes. The first such attempt was the neural networks of W. McCulloch and W. Pitts. After the development of learning algorithms, the resulting models began to be used for practical purposes: in forecasting problems, for pattern recognition, in control tasks, etc. An artificial neural network is a system of connected and interacting simple processors (artificial neurons). Such processors are usually quite simple (especially in comparison with processors used in personal computers). Each processor of such a network only deals with the signals it periodically receives, and the signals it periodically sends to other processors. And, nevertheless, being connected to a suficiently large network with controlled interaction, such separately simple processors together are able to perform rather complex tasks [2].

• From the point of view of machine learning, a neural network is a special case of methods for pattern recognition, discriminant analysis, clustering methods and so on.

• From the mathematical point of view, the training of neural networks is a multi parameter problem of nonlinear optimization.

 Printed in Kazakhstan

• From the point of view of cybernetics, the neural network is used in problems of adaptive control and as algorithms for robotics.

• From the point of view of the development of computer technology and programming, a neural network is a way of solving the problem of efiective parallelism.

And from the point of view of artificial intelligence, the artificial neural network is the basis of the philosophical trend of connectivism and the main direction in the structural approach to study the possibility of constructing (modeling) natural intelligence using computer algorithms. Neural networks are not programmed in the usual sense of the word, they are trained. The possibility of learning is one of the main advantages of neural networks over traditional algorithms. Technically, training is to find the coeficients of connections between neurons. In the process of learning, the neural network is able to detect complex dependencies between input data and output, and also perform generalization. This means that in case of successful learning the network will be able to return the correct result based on data that was not available in the training sample, as well as incomplete and / or "noisy partially distorted data [3].

Materials and methods

Most of the signals encountered in practice are represented in the time domain. And for most signal processing applications this view is not the best. In many cases, significant information is hidden in the frequency domain of the signal. To get the frequency representation, use the Fourier transform. The conversion formula is presented below [4-9]:

$$\widehat{f(\omega)} = \frac{1}{\sqrt{2\,\pi}} \int f(x) e^{-ixt} dx \qquad (1)$$

$i = \sqrt{-1}$

x – time

ω– frequency

f (x)– initial signal

$\widehat{f(x)}$– transformed signal

The method of wavelet transformation, in which the original discrete signal is decomposed into approximating and detailing values on different scales [10-14]. The wavelet transform method is based on the Fourier transform, but unlike it, thanks to this method, we were able to view the time-frequency representation of the signal.

The signal must be decomposed into sums of the product in the following form:

$$W(u,\alpha) = \frac{1}{\sqrt{\alpha}} \int f(t) \varphi \left(\frac{t-u}{\alpha}\right)^{*} dt \qquad (2)$$

$$\varphi(t) = \frac{1}{\sqrt{2\pi}\sigma} e^{-j\omega t} e^{-t/2\sigma^2} \qquad (3)$$

where φ(t) – mother Morlet wavelet,

W(u, α) – Wavelet transform,

α – scale coefficient,

u – shift coefficient,

f(t) – signal.

For example, if we consider the decomposition of the level 6 signal, medium values are discarded at each level and the detail values are remembered, at the very last level we have an average of level 6 and all the details of the previous levels [15].

For the experience, we studied the results of ECG images of 2000 patients from January 2017 to December 2017. P wave extension is associated with relapses of atrial fibrillation. Other studies have emphasized the importance of studying the morphology of P-waves, in predicting the recurrence of atrial fibrillation. Of these, 500 patients had the first episode, and 500 had a relapse episode of atrial fibrillation. Patients were observed for 12 months and classified into three groups, depending on the number of relapses of atrial fibrillation per year according Figure 1:

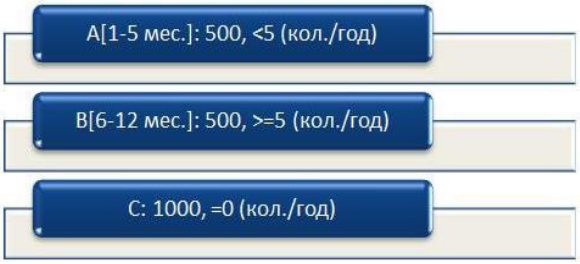

Figure 1 – Study groups

As a result of training, the neural network showed the following results – the network learned to recognize the disease, but in the early stages of its emergence to identify some signs was not able to. The application of the wavelet transform method distributed the group with early signs of the disease to the group of patients as in Figure 2:

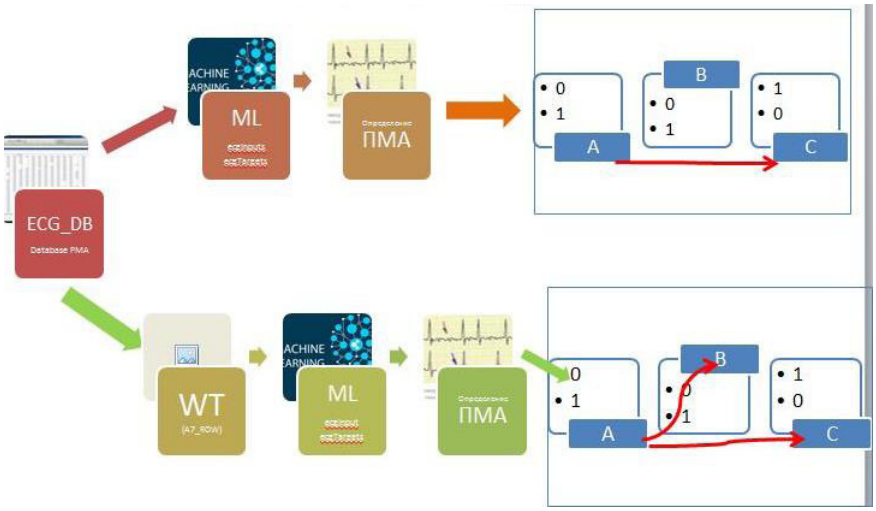

Figure 2 – Model of data processing

The neural network was trained based on 70 percent of the data from this database, 15 percent for validation, and the remaining 15 percent for network testing and the result of training on Figure 3:

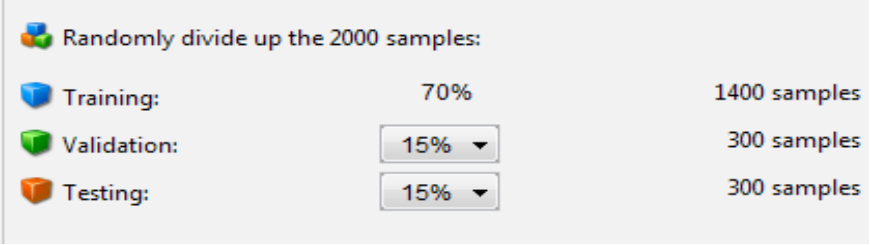

Figure 3 – Learning process

Main results

The accuracy of the algorithm is defined by the classical concept of confusion matrix [16-18] on Figure 4:

Figure 4 – Accuracy of the algorithm

TP – the experiment considers that the proof refers to class 0, and the algorithm also FP – experiment 1, algorithm 0. FN-experiment 0, algorithm 1. On the basis of this matrix, the precision was taken by 2000 data of ECG on the contiguity schedule, the accuracy was 0.85

Conclusion

An algorithm for digital data processing based on the wavelet transform method is developed;

Software modules have been developed for applying wavelet analysis to electrocardiogram (ECG) data;

A software module was developed and implemented to solve the main problems based on the built and trained neural network.

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