ECG analysis system, using a multi-layer neural network

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Abstract: In this article are presented the results obtained in the interpretation of a biomedical signal, electrocardiogram (ECG), by using a multilayer neural network, using the backpropagation algorithm. The neural network was simulated with the Neuroshell program. The new obtained network was used within the program of automate diagnosing of the ECG

Keywords: *ECG, neural network, hidden layer, backpropagation, P waves, QRS complex, T wave*

The ECG signal represents the electrical activity of a heart, is a periodical and analogical signal, and a full cycle of the signal represents a heart contraction. The electrocardiogram is using for the heart diseases diagnose, being a non-invasive method of exploration [1]. The electrocardiogram is present in figure 1.

In an electrocardiogram there can be noticed several characteristic sectors [1]:

- P wave;
- QRS complex;
- T wave.

Also, in figure above, can be noticed that the R peak is always the point in which the signal reaches the maximum amplitude.

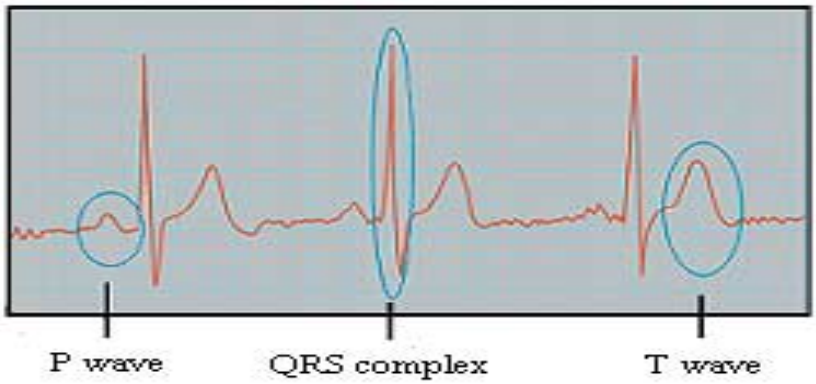

Figure 1. The main components of an ECG signal

Initially, the ECG the program takes the signal by means of an acquisition card, then the signal is digitized and quantified. The signal is stored in files. The program extracts the samples from files, memorizes into internal variables and begins the processing. A first operation made over the samples is filtering, the filtered signal being displayed on screen. The filtered signal is divided into three components. A local neural network processes each of these components and outputs a number that characterizes the component. The result of processing is taken by the diagnosis network, which forms, with other variables, the inputs for the diagnosis neural network. The structure of the diagnosis program and the connections among modules are shown below:

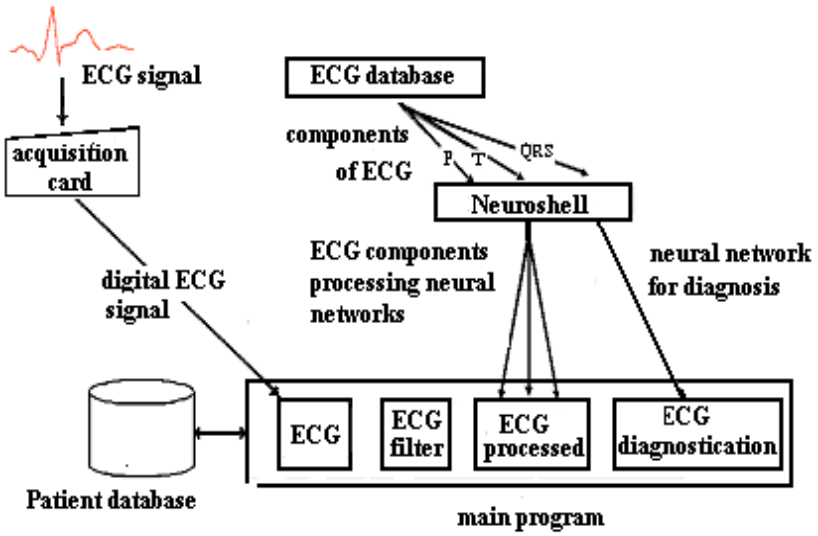

Figure 2. ECG analysis systems

For the analysis of these three components of the ECG signal and for diagnostication it was used a multilayer neural network, with supervised training using the backpropagation algorithm. The configuration of the four networks corresponds to:

- Input layer
- Hidden layer
- Output layer

The difference between the networks consist in the number of neurons from the each layer[3]. The hidden layer was divided in three individual groups, each of them having in their componence the same number of neurons, 6 neurons for the P wave, 8 neurons for the QRS complex, 14 neurons for the T wave and 7 neurons for diagnosis. The functions of neurons activation for in these hidden groups are different[3]:

- The gaussian function for the first plate
- The hyperbolic tangential function for the second plate
- The complementary gaussian function for three plate

The combinations between the three outputs of the hidden plates will represent inputs for the output layer. The output layer for diagnosing needs 15 neurons, one for each disease recognitions and one neuron for processing three components of ECG signal. A neural network with a single hidden layer, but divided in three sublayer has the configuration as in figure [3]

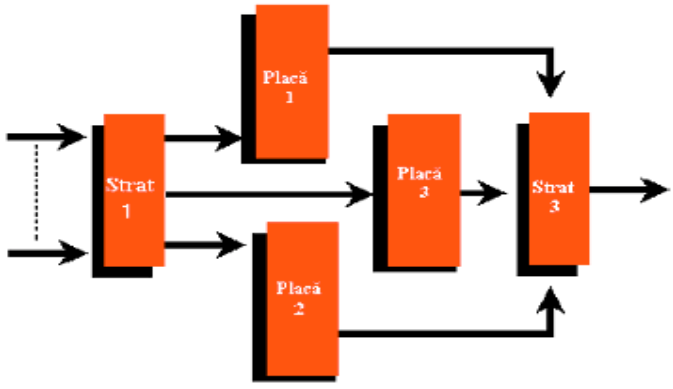

Figure 3. The neural network used for simulation.

The networks were created using the NeuroShell2 program. For the network training it was used a set of 100 pair of input vector – output vector. The learning was stopped when the error calculated between the expected output and the network's answer was smaller then 0,000001.

The neural networks were used within the program of ECG automate diagnose. The program works under Windows 98 operating system and was built in Borland C++ 6.0 Builder. The figure 4 shows the main interface for diagnose.

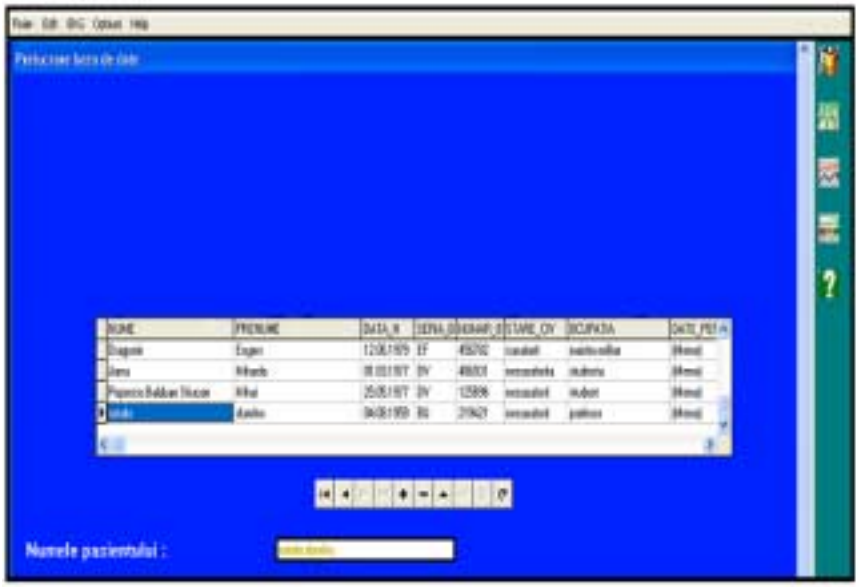

Figure 4. The main diagnosis window.

There are three possibilities to display the patient's ECG signal: filtered, unfiltered or processed (figure 5) as well as the diagnosis (figure 6).

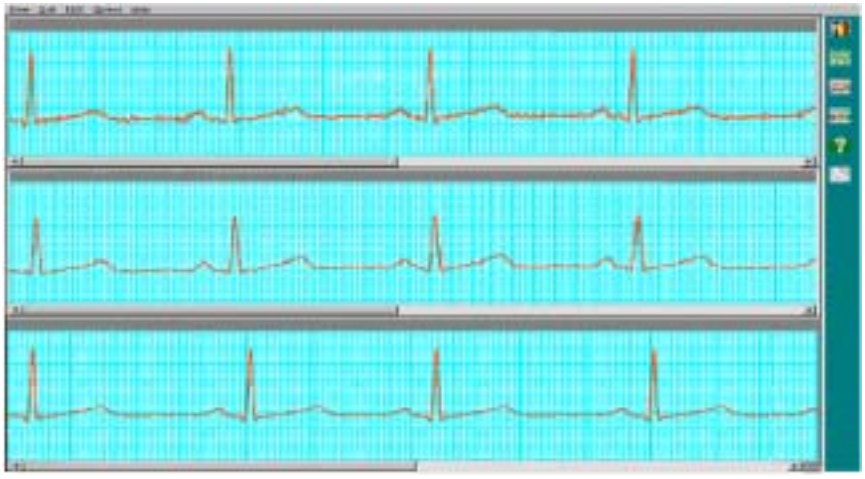

Figure 5. The ECG signal

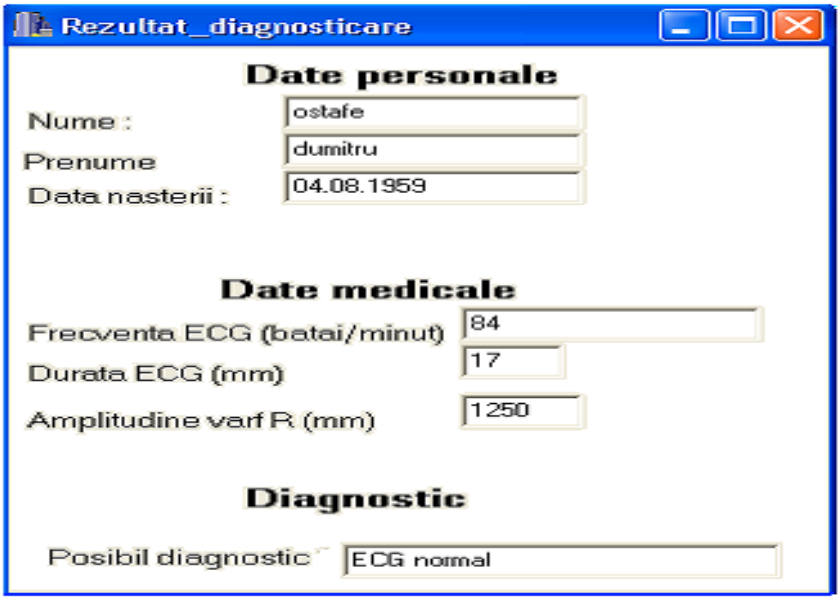

Figure 6. The diagnosis window.

Conclusion

Neural Networks can be successfully applied for medical diagnosis if a sufficient number of training data is available.

The ECG analysis system can diagnose 15 diseases; the most important being: bradycardia, tachycardia, heart block, atrial fibrillation, and 1st degree heart block.

References

[1] Dale Dubin, M.D., "Informatică Medicală, Interpretarea Rapidă a ECG" Editura Medicală, Bucureşti, 1983

[2] Van der Smagt, P., Krose, B., "An Introduction to Neural Networks", Amsterdam, 1994.

[3] Ward Systems Group Inc. - "NeuroShell2", Ed. Ward Systems Group, 1999