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INTERPRETATION OF SIGNAL BY USING NEURAL NETWORKS

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Abstract. *In this paper there are introduced the results obtained in the interpretation of the components of a biomedical signal, ECG, by using a neural network, using the backpropagation algorithm. The neural network was simulated with the Neuroshell2.0 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*

Introduction

There is a large range of traditional algorithms for signal interpretation, but there are also problems for which there are no traditional solutions. The neural networks are in this case a solution by their ability to solve such problems.
Several mathematically optimal algorithms are not useful in practice. The most frequent problem is that of noise contamination of the signal. Neural networks are quite tolerant to noise distribution. When the neural networks are used in real life situation then may overcome their equivalents mathematical optimal.
Another reason for the need to consider the alternatives of the neural networks, instead of theoretically superior traditional models, is that the former can be quicker. Several applications of signal interpretation must be performed in real time. Neural network are not just quicker, they are also parallel. When the solution requires a parallel interpretation, neural networks are better than traditional methods, which may have difficulties in this case. Also, a viable traditional solution for the present problem may not exist. On the other hand, neural networks are well known for finding solutions to confusing problems. It is sometimes cheaper and easier to have the problem solved by neural networks, better suited to find solutions.

ECG signal

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 corresponding of a fully heart cycle is present in figure 1.

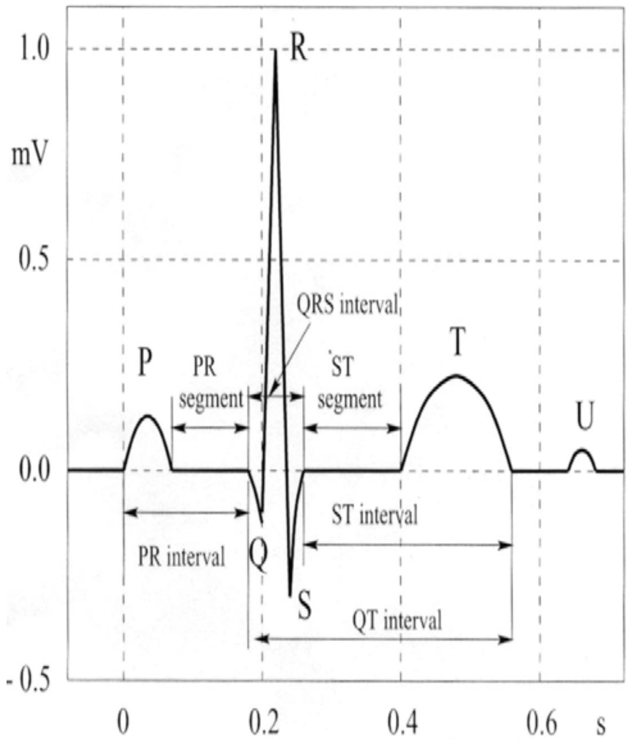
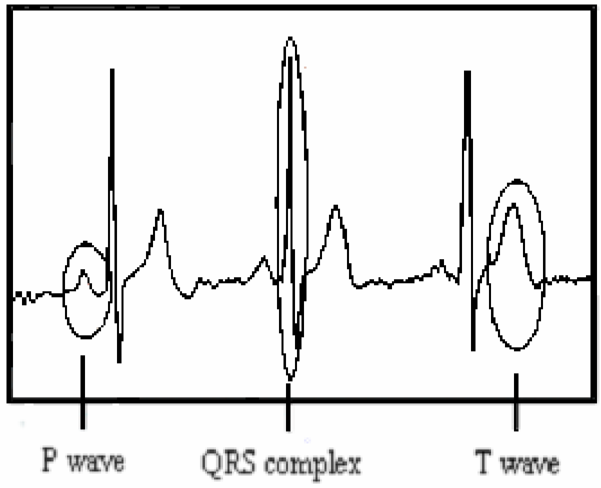


Fig.1Electrocardiogram

In an electrocardiogram there can be noticed several characteristic sectors [1], the P wave, the QRS complex and the T wave. Also, it is noticed that the R peak is always the point, in which the signal reaches the maximum amplitude, as it is



shown in figure 2

Fig. 2 Main components of an ECG signal

This property will be used for dividing the ECG signal in sectors. The first phase in processing the ECG signals consists in extracting the highly important information from a signal recording, meaning to find the three components: the P wave, the QRS complex and the T wave. Each of these three components has own features and forms A neural network will process each of the extracted components. Each of the three components consists of a certain number of samples- the input data in the neural network. As output we shall a number that will classify each of three components in various categories. Thus, we have the following table:

Component	**Property**	**Output value**
P wave	Normal	10 ÷ 29
	Mitral	30 ÷ 39
	Isoelectric	0 ÷ 9
QRS complex	Q greater than 0,40 s	10 ÷ 19
	S wide and deep	30 ÷ 39
	S great in comparison with R	40 ÷ 49
	Under-denivelation ST	20 ÷ 29
	Normal	0 ÷ 9
T wave	Tall and pointed	10 ÷ 19
	Normal	0 ÷ 9

As it comes out from the table, to each of the features of component corresponds a certain value in an interval.

Neural network

For the analysis of these three components it was used a neural network, that were simulated with the Neuroshell 2.0 program. Each of the three neural networks has a set of sampled as input. As output a number. As it was mentioned above, each of the components of the ECG signal are processed by a neural network. We shall have three neural networks, one for each component, because the ECG signal consists of three components (the P wave, the QRS complex and the T wave). The configuration of the three networks corresponds to the multi-layer type, with hidden layers. The differences between the three networks consist in the number of neurons from input and hidden layer. Here are the number of neurons in each layer, that correspond to each component [2],[3]:

For the P wave

- the input layer 25 neurons
- a hidden layer with 18 neurons
- the output layer 1 neuron

For the QRS complex

- the input layer 31 neurons
- a hidden layer with 24 neurons
- the output layer 1 neuron

For the T wave

- the input layer 71 neurons
- a hidden layer with 42 neurons
- the output layer 1 neuron

For the input layer the neurons are integers, and the activation function is a linear function with values varying between [-1,1], and for the hidden and output layers it was choosen the function of logistic activation.

In this application, there were used three types of neuronal networks with a single, two and three hidden layer.

A neuronal network with a single hidden layer has the configuration as in figure 3.

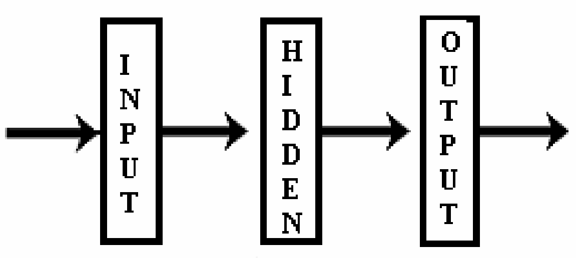


Fig. 3 neural network with a single hidden layer

A neuronal network with two hidden layers has the configuration as in figure 4.

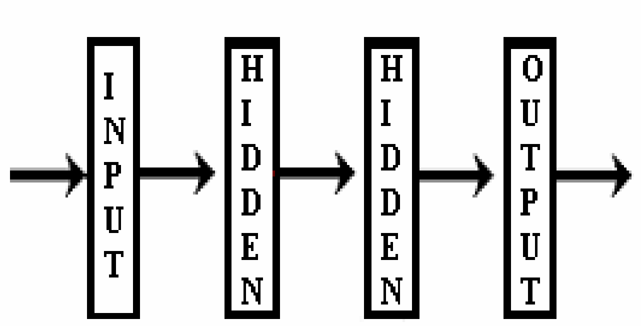


Fig. 4 neural network with two hidden layers

A neuronal network with three hidden layers has the configuration as in figure 5.

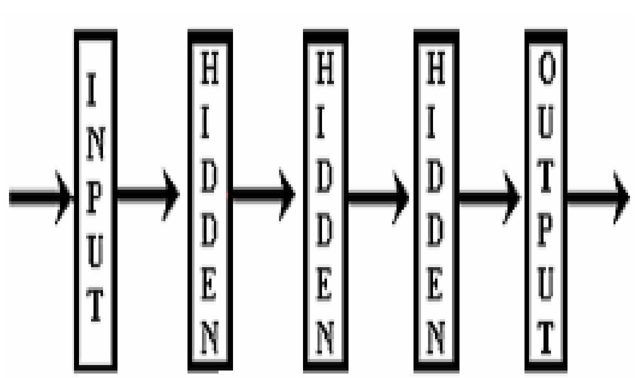


Fig. 5 neural network with three hidden layers

The hidden layers, each of them having in their component the same number of neurons (divided in one, two or three layers).

The networks were created with the help of the Neuroshell program. For network training it was used a set of 100 pairs of input vector – output vector. The learning was stopped when the error calculated between the expected output and the network's answer were small then 0,00001.

Results for the P wave, for a neural network with a single hidden layer

In the following table there are listed the results obtained with the neuroshell program for the P wave:

Output:

R squared:	0,965
r squared:	0,9668
Mean squared error:	1,97
Mean absolute error:	0,368
Min. absolute error:	0
Max. absolute error:	11
Correlation coefficient r:	0,9833
Percent within 5%:	87
Percent within 5% to 10%:	7
Percent within 10% to 20%:	2
Percent within 20% to 30%:	0
Percent over 30%:	2

In figure 6 it is present the error for the P wave for a neural network with a single hidden layer.

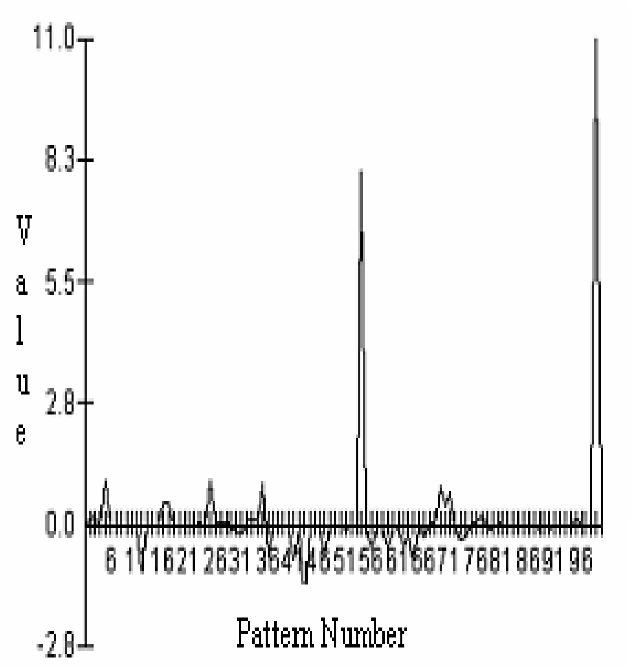


Fig. 6 Error for the P wave

Results for the P wave, for a neural network with two hidden layer

In the following table there are listed the results obtained with the neuroshell program for the P wave:

Output:	
R squared:	0,9942
r squared:	0,9943
Mean squared error:	0,328
Mean absolute error:	0,239
Min. absolute error:	0
Max. absolute error:	3,65
Correlation coefficient r:	0,9971
Percent within 5%:	87
Percent within 5% to 10%:	8
Percent within 10% to 20%:	2
Percent within 20% to 30%:	0
Percent over 30%:	1

In figure 7 it is introduced the error of the neural network for the P wave

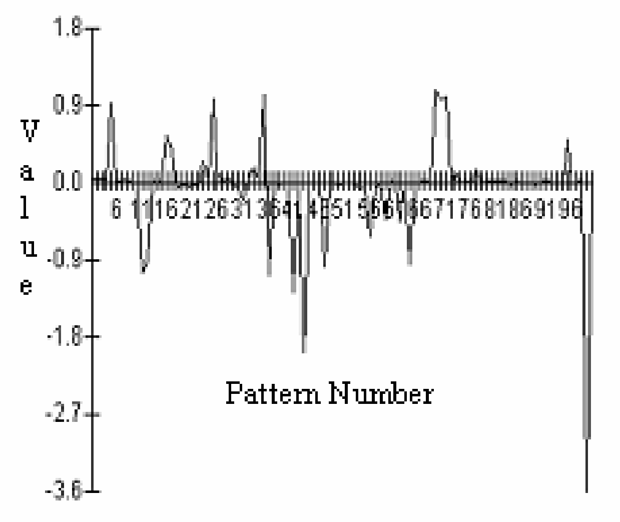


Fig. 7 Error for the P wave

Results for the P wave, for a neural network with three hidden layer

In the following table there are listed the results obtained with the neuroshell program for the P wave:

Output:	
R squared:	0.9979
r squared:	0.9979
Mean squared error:	0.118
Mean absolute error:	0.202
Min. absolute error:	0
Max. absolute error:	1.568
Correlation coefficient r:	0.999
Percent within 5%:	89
Percent within 5% to 10%:	7
Percent within 10% to 20%:	2
Percent within 20% to 30%:	0
Percent over 30%:	0

In figure 8 it is introduced the error of the neural network for the P wave

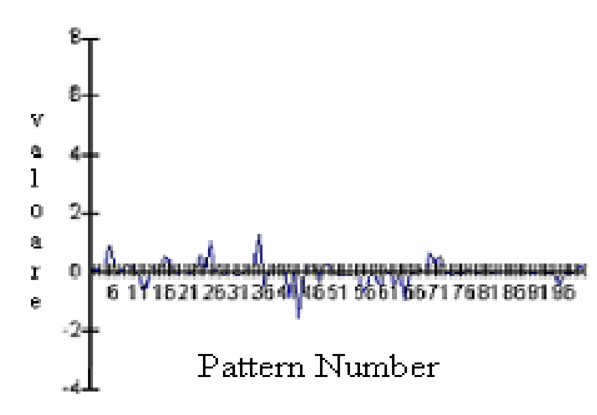


Fig. 8 Error for the P wave

Conclusions

By comparing the results it is noticed a neuronal network with three hidden leyers is optimal, the results beign better (as final error). These results are got also for other two waves of the ECG signal, namely the QRS complex and the P wave.

References

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