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Application of Artificial Neural Networks in the Heart Electrical Axis Position Conclusion Modeling

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Abstract. The article touches upon building of a heart electrical axis position conclusion model using an artificial neural network. The input signals of the neural network are the values of deflections Q, R and S; and the output signal is the value of the heart electrical axis position. Training of the network is carried out by the error propagation method. The test results allow concluding that the created neural network makes a conclusion with a high degree of accuracy.

1. Introduction

The Electric Axis of Heart (EAH) [1] – the term used in cardiology and functional diagnostics, reflecting the electric processes happening in heart. The electrocardiogram is a schedule of temporary dependence of a potential difference in the corresponding assignment, and temporary dependence of a projection of a complex electric vector of heart to the line of assignment. The direction of an electric axis of heart shows the total amount of the bioelectric changes proceeding in a cardiac muscle at each her contraction.

The conclusion "turn of an electric axis of heart around an axis" quite often can occur in descriptions of electrocardiograms. The provision of an electric axis of heart serves as an additional indicator at diagnosis of this or that disease. The provision of an electric axis in itself hearts isn't the diagnosis. However there is a number of diseases at which is observed shift of heart axis.

Currently, the development of medicine is based on the use of human-machine (automated) methods of information processing for the improvement of decision making in the disease diagnostics. Mathematical and algorithmic support of management and decision making, as well as obtaining expert information, analysis and processing methods are already known in different fields [2-9]. Now research works on application of artificial neural networks in the field of medicine and in particular in cardiology are conducted [10-12]. Enhancement of effective functioning of biotechnical systems for the scientific activity planning, data collection and analysis, using modern methods of information computer processing is becoming urgent, giving the most labor-consuming and important process in the diagnosis and prognosis of human life parameters to appropriate hardware and software means of simulating the medical experts activities.

2. Goal Setting

Research and study of artificial neural networks capabilities (ANN) is one of the promising areas of Medical Informatics. The objective of this work is modeling a conclusion about the heart electrical axis position using an artificial neural network. To achieve this goal it is necessary to accomplish the following tasks:

1. To form a training sample;
2. To select an ANN model;
3. To test the case study of the selected model.

The problem of diagnosing of deviations of an electrocardiogram from norm can be carried to problems of recognition of images. Image is the system of classification allocating a certain group of objects on some sign. Research in this work of an artificial neural network as the classifier is caused by her ability to processing of indistinct and difficult basic data for their classification [12]. When teeth of R are accurately visible, then it is easy for doctor or student to define the provision of an electric axis of heart. But happens that teeth R approximately identical amplitudes, data can be not full or inconsistent then the program can come to the rescue.

According to the available sources, there are no examples of making conclusion about the heart electrical axis position using an artificial neural network. Practical application of the MATLAB source environment is currently being actively developed and is the core technology for Biomedicine tasks simulations.

2. An artificial neural network design, modeling and training.

2.1 Training sample formation

To form a training sample the source data [1] were entered into MS Excel table (figure 1). The training sample is the values of deflections Q, R and S amplitudes in standard leads I, II and III calculated by the formula (1):

$$U = h \times S \tag{1}$$

where U is the amplitude (mV),
h is the height of deflections (mm)
S is the height of the calibration signal (mm).

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	A	B	C	D	E	F	G	H	I	J	L
1	№	IQ	IR	IS	IIQ	IIR	IIS	IIIQ	IIIR	IIIS	Conclusion
2	1	0,00	0,50	0,10	0,00	0,40	-0,10	0,00	0,10	-0,20	3
3	2	0,00	0,40	0,00	0,00	0,25	-0,40	0,00	-0,40	0,00	1
4	3	0,00	0,60	0,00	0,00	0,60	0,00	0,10	-0,10	0,10	3
5	4	-0,10	0,50	-0,10	-0,30	1,70	-0,10	-0,20	1,30	-0,10	5
6	5	-0,10	0,40	-0,10	0,00	0,50	-0,10	0,00	0,10	-0,10	3
7	6	-0,10	0,50	0,00	-0,50	0,60	-0,50	-0,10	0,40	-0,20	3
8	7	-0,10	0,20	-0,10	0,10	0,50	0,00	0,00	0,10	-0,10	3
9	8	-0,10	0,90	-0,20	-0,10	0,50	-0,30	0,10	-0,30	0,00	2
10	9	-0,10	1,10	-0,10	0,00	0,90	0,10	0,00	-0,20	0,00	3
11	10	-0,10	0,60	-0,20	-0,10	0,60	-0,20	-0,10	0,10	0,20	5
12	11	0,00	0,30	-0,10	0,00	1,50	0,00	-0,10	1,20	0,00	5
13	12	-0,20	0,60	-0,20	-0,10	0,60	0,00	-0,10	0,30	0,00	4
14	13	-0,10	0,80	-0,10	-0,20	0,40	-0,20	-0,10	-0,40	0,00	1
15	14	0,00	0,70	-0,30	-0,10	0,90	0,00	-0,20	0,60	0,00	4
16	15	0,00	0,60	0,00	-0,10	0,90	-0,10	-0,10	0,30	-0,10	3
17	16	0,00	0,20	-0,10	0,00	1,40	0,00	0,00	1,20	0,00	5
18	17	-2,00	-0,28	1,60	-1,36	-1,48	-0,12	1,92	1,92	-1,44	3
19	18	-0,80	-0,24	1,52	-0,52	1,80	-0,20	0,84	-1,60	-1,64	2
20	19	0,84	0,40	-0,56	0,24	0,72	-1,08	0,32	1,64	1,80	2
21	20	-0,92	0,52	-0,80	0,96	-1,16	0,08	1,24	1,44	-0,84	2
22	21	-1,72	1,08	-1,12	0,12	0,68	-0,12	1,32	-1,04	-1,76	2
23	22	-1,72	-1,40	-1,08	0,36	0,60	0,12	1,76	0,24	-0,08	1
24	23	-0,52	0,60	-1,92	1,76	-0,32	-1,04	0,12	1,40	1,68	1
25	24	0,00	0,04	-0,40	1,24	-0,36	1,88	-0,44	-1,60	0,04	3
26	25	-2,00	1,28	-1,60	-0,76	0,36	-1,76	1,28	1,72	0,08	2
27	26	-1,12	0,92	-0,76	0,68	0,24	-1,00	-1,32	-0,64	1,04	1
28	27	1,64	1,64	1,96	-1,40	1,04	2,00	1,68	-1,84	-0,72	3
29	28	1,64	1,52	1,48	-0,28	-0,72	0,96	-1,60	0,04	-1,00	1
30	29	-0,92	1,16	1,68	-1,76	0,68	1,60	1,36	-1,60	-1,52	2
31	30	0,92	-1,84	-1,12	-1,72	0,04	-1,24	-0,12	-1,20	0,96	3
32	31	-0,36	-0,76	-1,56	-0,84	0,84	-1,64	-1,24	-0,52	-1,68	1
33	32	-0,52	1,88	-0,24	-1,16	1,52	-1,84	1,00	-1,40	1,76	3
34	33	0,56	0,00	-0,32	0,44	-0,56	1,80	0,64	-0,24	1,92	1
35	34	-0,80	0,48	0,92	-1,84	-1,72	1,84	0,72	1,12	-0,40	3
36	35	1,92	1,56	1,92	0,16	-1,80	-0,56	0,16	-0,16	-1,32	4
37	36	1,88	0,24	-0,32	-1,24	-1,12	0,44	0,92	-1,52	0,20	3
38	37	0,08	-1,72	-1,92	1,92	1,12	0,96	1,28	1,96	0,16	5
39	38	0,64	-1,52	-1,60	-0,68	-1,04	-0,52	-1,36	1,20	-0,56	3
40	39	-0,72	-0,40	-2,00	-1,28	-1,16	0,12	0,20	1,00	-0,44	3
41	40	-1,92	-0,92	-1,80	0,16	-1,68	0,68	0,12	-0,40	0,16	3
42	41	1,84	1,76	-0,04	1,04	-0,84	1,96	-1,40	-0,84	-1,72	2
43	42	-1,92	1,68	0,20	-0,20	-0,20	-0,56	0,76	1,52	-1,44	3

Figure 1 - MS Excel sheet working area with source data

In the source data it is also necessary to calculate the algebraic sum of deflections Q, R and S for every standard lead and angle α (2), which connects the heart electrical axis with the first lead axis:

$$tg\alpha = \frac{1}{\sqrt{3}} \frac{\sum_{II} + \sum_{III}}{\sum_{II} - \sum_{III}} \quad (2)$$

where Σ_{II} is the algebraic sum of deflections Q, R and S in the second lead,
Σ_{III} is the algebraic sum of deflections Q, R and S in the third lead.

2.2 Model selection and artificial neural network training

Due to the fact, that in the source data there are 6 classes (table 1), i.e. values of the heart electric axis position angles (figures 2, 3), a multilayer neural network was selected for conclusion modeling. Such an ANN model will provide an effective solution to the problem of image classification.

MATLAB, which has several advantages [13] and has been widely used in intelligent and expert systems [14-16], was selected as an algorithm implementation source environment.

Table 1 – Heart electrical axis position by the value of angle α

Angle value	№	Heart electrical axis position
less (-30°)	1	Left anterior fascicular block
(-30°) - 0°	2	Sharp levocardiogram
0° - 50°	3	Levocardiogram
50° - 70°	4	Normocardiogram (normal axis position)
70° - 90°	5	Dextrogram
90° - 97°	6	Left posterior hemiblock

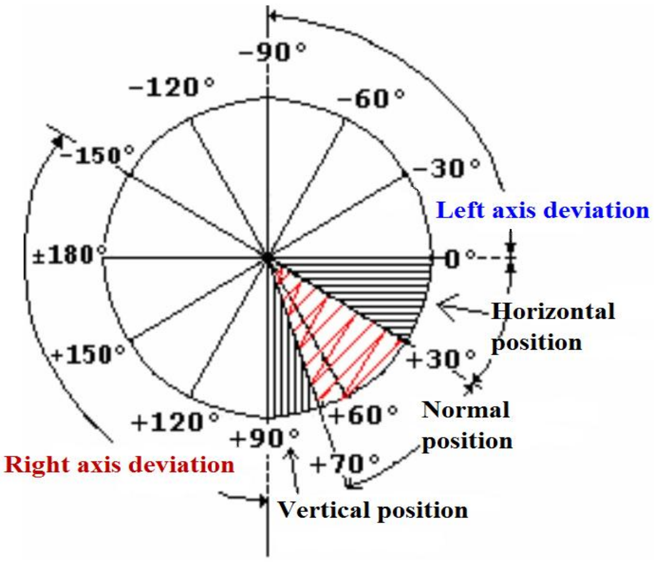

Figure 2 – Variants of heart electrical axis position

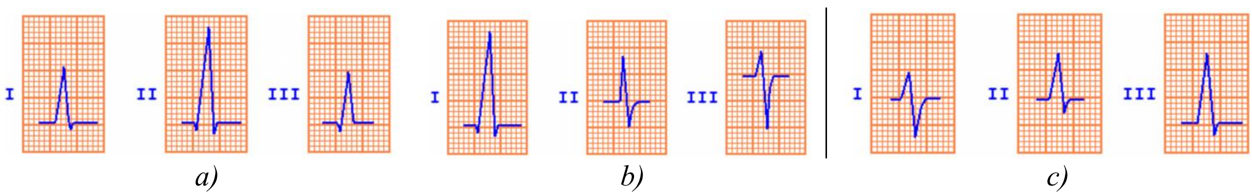

Figure 3 – *a)* Normocardiogram, *b)* Levocardiogram, *c)* Dextrogram

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On the basic data is picked the architecture of an artificial neural network: multilayered perceptron, weight coefficients at this stage of work are accepted equal to zero, sigmoidalny activation function. The quantity of layers and amount of neurons in each layer retrieved experimentally.

The selected ANN model case study was accomplished using the built-in function *trainlm*, which implements the back propagation method with adjustment rate perturbation and adaptation, and the *learngdm* team realizing of algorithm of fine tuning of scales. In entrance, the first and second layers function of activation *tansig*, in the third – *logsig*, in the fourth – *tansig*, in an output layer – *purelin* is used. The assigned number of training cycles equaled to 1000 epochs (figure 4):

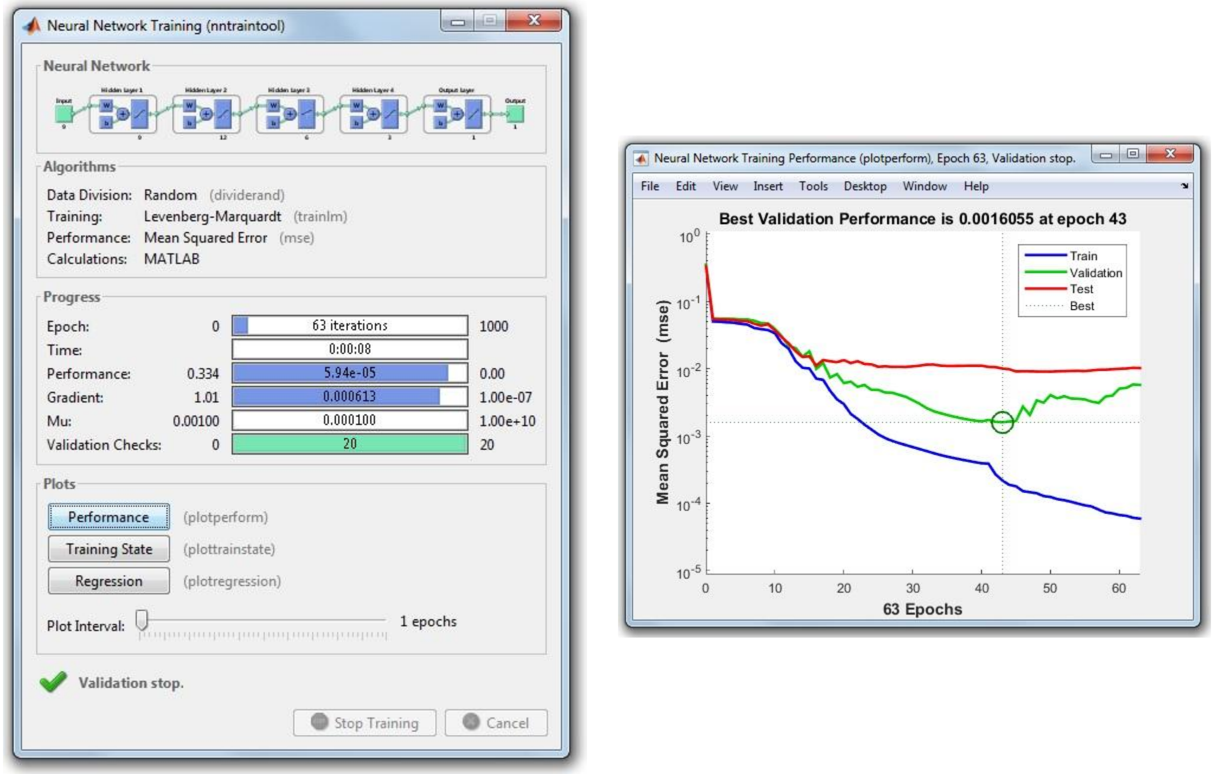

Figure 4 – Window of network training results

When the number of error count reaches the authorized number, the ANN training stops. In this case 63 epochs were processed; the best value was obtained in epoch 43 (which is shown on the MATLAB graph, figure 4). As soon as the training ended, the program opens a dialog window and an expert medic enters the electrocardiogram (ECG) initial data (figures 5, 6).

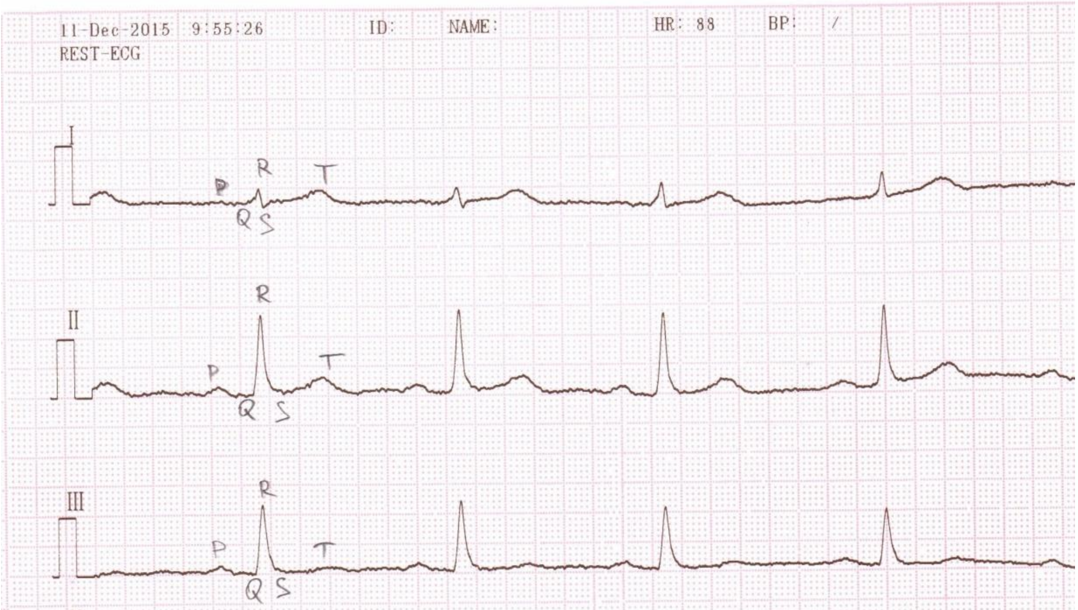

Figure 5 – Patient's ECG

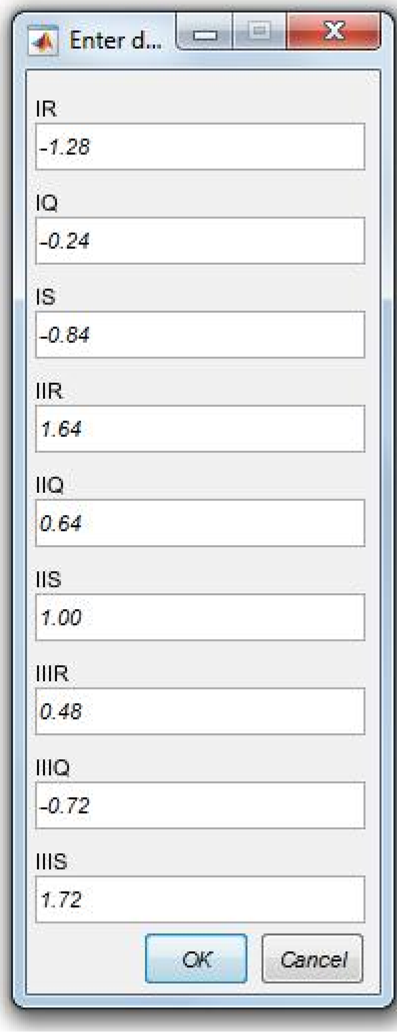

Figure 6 – Dialogue window for entering deflection values

After the patient's ECG values are entered the neural network outputs the result according to table 1 (figure 7).

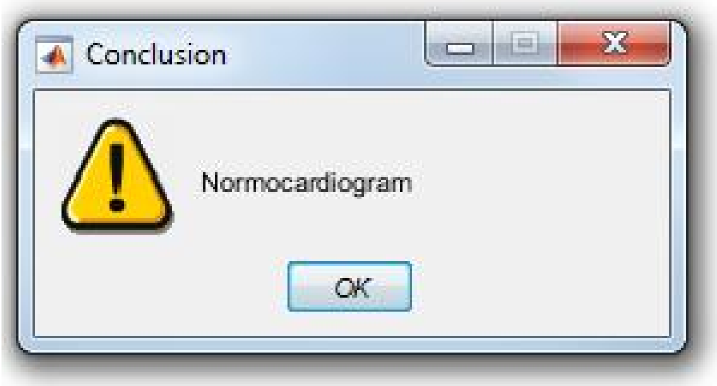

Figure 7 – Conclusion about a heart electrical axis position

3. Conclusion

The artificial neural network training with the use of the back-propagation method based on 2000 variants of deflections Q, R and S values showed the conclusions plausibility. The training results show that ANNs have high potential for the development of methods and algorithms of the heart electrical axis position calculation modeling and for further work to identify deviations in electrocardiograms.

The work is perspective for further development. So at the following stage is considered the possibility of automatic receiving basic data for performance of calculations from the digitized image of an electrocardiogram.

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