Integrated Approach to Improve Reliability of Neural Network

Mary Tyagunova, Tanya Golub, Andrey Proskura

***Abstract*—** This article describes complex approach to improve the reliability of neural networks. As a basis it is taken Kohonen neural network, which solves the problem of clustering graphics sets of different signals, ensuring optimum reliability and quality performance. The main test results are given.

***Keywords*—** neural network, reliability, SOM Kohonen.

I. Introduction

At the present stage of development and applications of neural networks actual direction is to work with graphical data.

Selection images as an input data are related with the study of perspective directions of Kohonen neural network development. Namely, their narrow specialized direction is to work with images that, at this stage of neural networks development is an urgent task. Currently, the development of processing technologies different images, which have different size and quality is very important and relevant. Therefore work with images, not with numerical data is very important, despite the complexity of the problem since the task of clustering antecedent to recognition, i.e. it is an important preparatory step in the recognition process. An important feature of using Kohonen networks is the technology (method) unsupervised learning that significantly affects to the results of using this approach.

Taking into account that created neural network should provide the high level quality of the task performance, there is a question about the feasibility of improving the reliability of its functioning, which in the future will have a direct impact on the quality of its work and the results of clustering. Thus, the chosen theme is relevant.

Analysis methods for improving the reliability are described in [1] in sufficient detail, so attention is paid that it is distinguish functional and parametric [2] reliability. Each method has its advantages and disadvantages. In this paper we propose a comprehensive approach to improve the neural network reliability.

II. An Integrated Approach to Improve the Neural Network Reliability

It takes at the basis that the weights of all the neurons and their thresholds are random variables that obey the normal law of probability distributions with known parameters. Based on this knowledge and tailored the identified positive aspects of approaches and improve functional parametric reliability, conducted the study it allocates the following recommendations for an integrated approach to improve the neural network reliability:

1. An increase of the functional reliability of the entire neural network is more rational to introduce a static redundancy, as it has several advantages over other types of redundancy. The important advantage of static redundancy is its flexibility and lack of the need to develop special software for the detection, localization and bug fixes, error correction, without interruption in the operation.

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2. At increase parametric reliability should be guided by the fact that when an equal number of neurons, the structure of the neural network with a large number of layers has a much lower probability of failure-free operation than the structure with less number; also reliability increases with the growth of quantity (number) of neurons in the first layer of the multilayer neural network, i.e. with the introduction of static redundancy. And if it is introduced into the second and subsequent layers of neural network, reliability is significantly reduced.

Summarizing the above recommendations, it should be noted that the increase in the parametric reliability should be accompanied by an increase in the functional reliability, i.e. use an integrated approach. In turn, increase the parametric reliability by reducing the number of layers and increasing the number of neurons in the first layer by the introducing a static redundancy.

To test the integrated approach to improving the reliability has been implemented the Kohonen neural network, which solves the problem of clustering graphics sets of different signals, ensuring optimum reliability and functioning quality. The importance of addressing this problem is described in more detail in [3].

III. DEVELOPMENT OF THE NEURAL NETWORK

For the check on the practice of the integrated approach has been designed self-adjusting Kohonen neural network and conducted its test. Fig. 1 shows the control window of created neural network, which is the final stage of the simulation. In this window, are given the opportunity to make adjustments to the configuration and further operation of the created neural network. Among them are: re-training (Train Again), change the number of neurons in layers (Adjust Network Size), import a large volumes of data (Import Large Data Set), Network Testing (Test Network), change the type and the kind of the incoming data (Inputs).

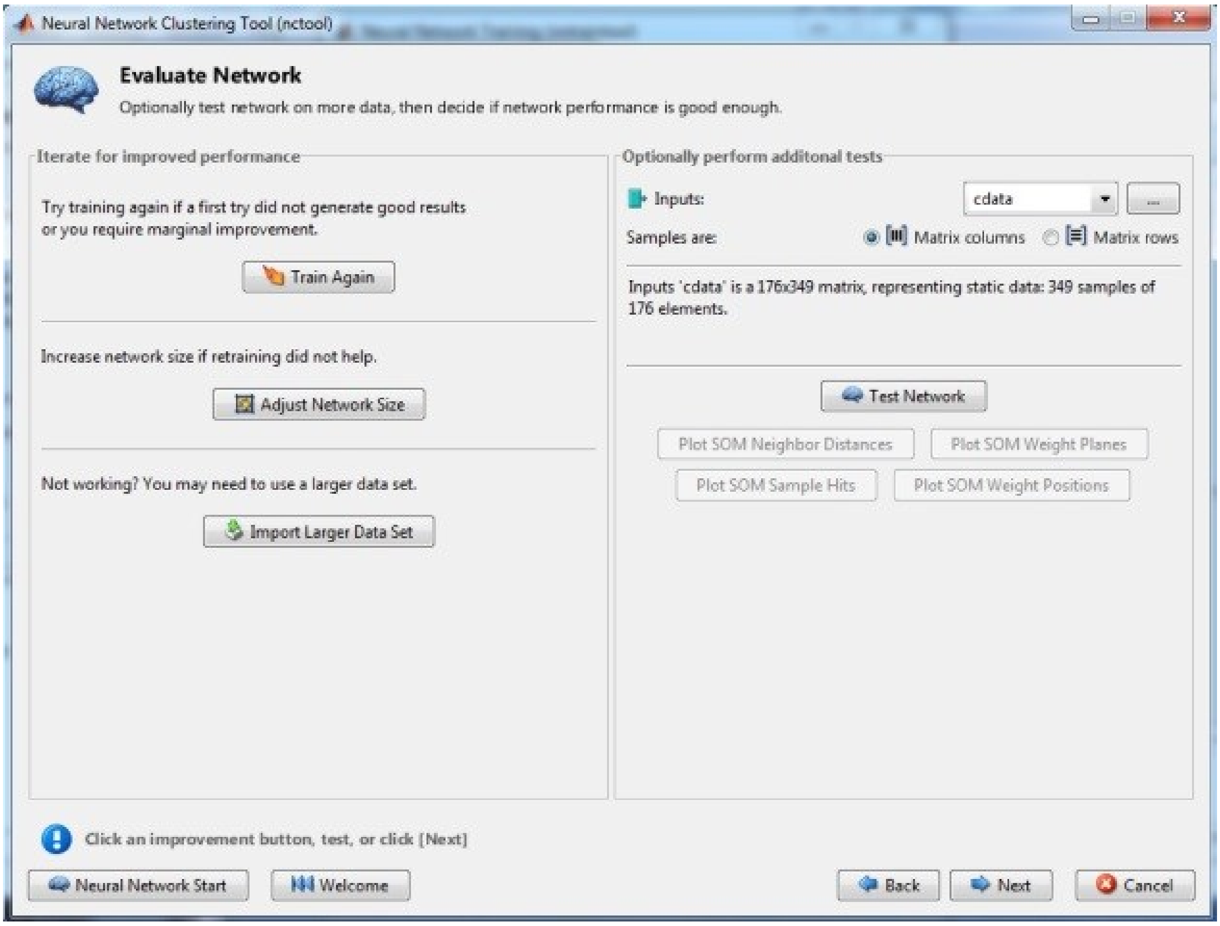

Fig. 1 Window management of created neural network

After testing the network it is opportunity to see results of the created neural network, which are displayed with the following options:

- plot Self Organization Maps (SOM) Neighbor Distances;
- plot SOM Weight Planes;
- plot SOM Sample Hits;
- plot SOM Weight Positions.

A. Input Data

The data used as an input data for teaching, training and testing the developed neural networks have the form of images with several signal periods which have different mathematical and physical models, as well as arguments, functions and parameters.

At various stages of the design used different sets of data (signal images), which included the types of signals such as modulated, harmonic, sawtooth. The neural network has distributed corresponding images sets to the relevant clusters at certain stages of its creation. Respectively used in the design process and improve the reliability of the neural network training and test sets contained images of various kinds of signals for more correct and independent results of research and work of the neural network.

As an important feature of using Kohonen networks is a method of learning without a teacher, which significantly affects to the results when using this approach, the results of training, testing, and clustering process directly depends only on the structure of the input data.

Different sets of data (signal image) generated at various stages in the applied mathematical package MatCad15.

B. Training Set

The training set consists of 14 similar images of signals which vary harmonically. Some of them are influenced by noise. Some images of the data set are presented in Fig. 2.

Signals from this training set are sine and cosine. They have different amplitude, frequency and presents respective different number of periods.

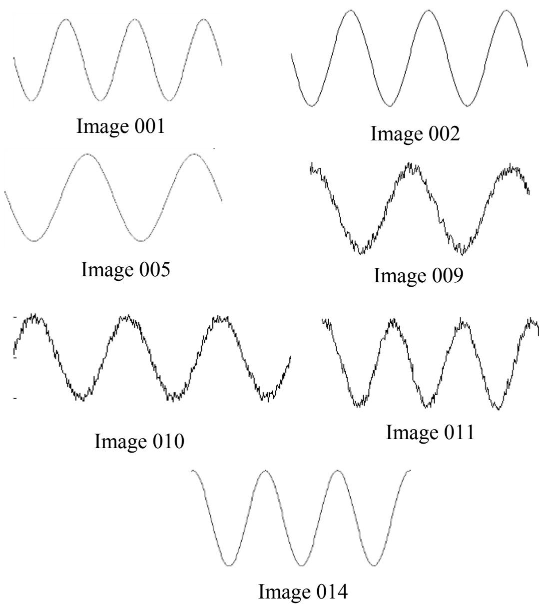

Fig. 2 Training data set

C. Test Set

The test signal set includes 12 images. At the generation signals in the system MathCad15 was created 2 obvious signal groups on 3 images in each, further suggesting that the created neural network distributes their according to expected clusters. The remaining 6 images of signals are generated with more significant differences in the parameters and arguments, as well as noise levels. It is expected that the system distributes them in 2 clusters on 3 in each. The following fig. 3 shows a complete test set of images with the expected distribution them of clusters on the test.

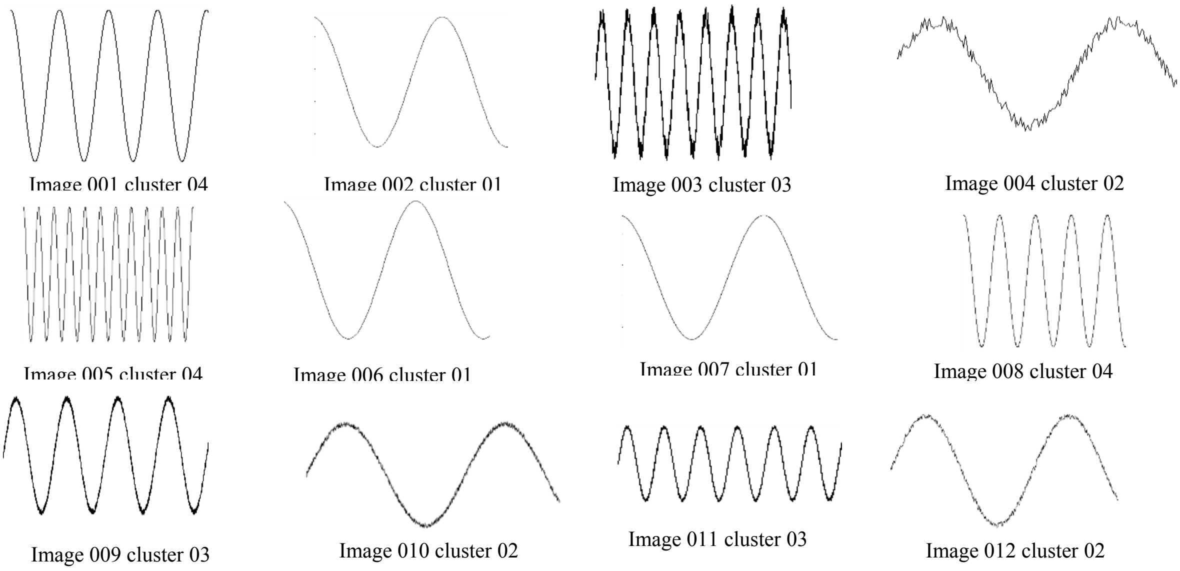

Fig. 3 Test data set

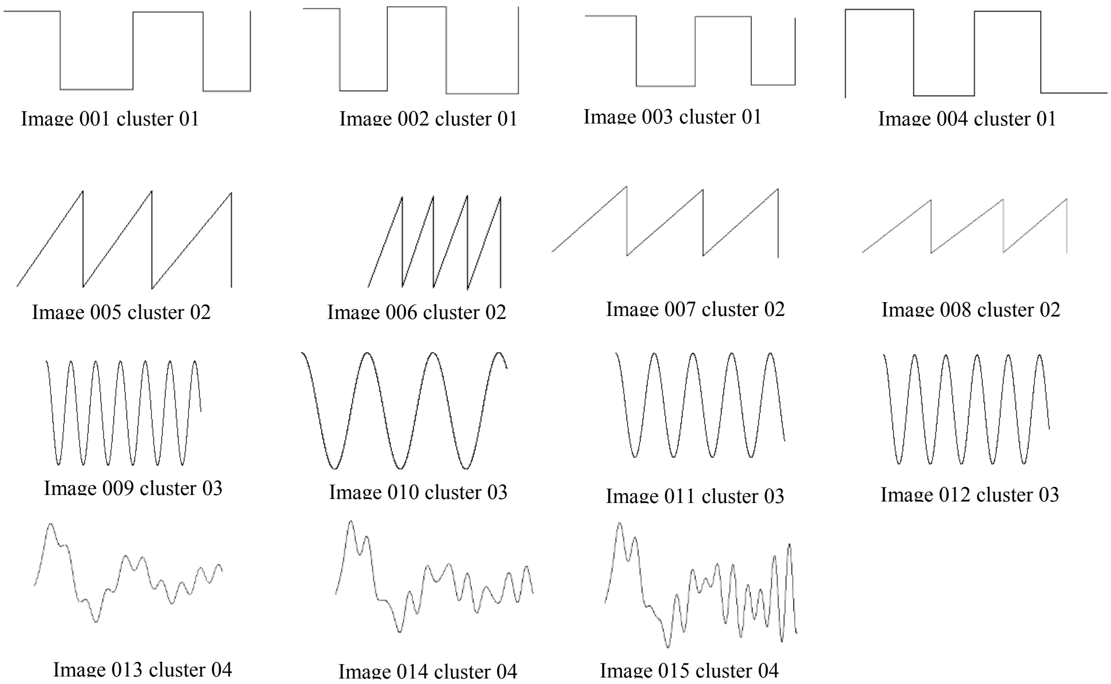

Fig. 4 The data set for clustering

The testing process will be considered successful if the neural network will distribute these 12 images on a 4 clusters, given the recommendations that have been developed in the generation of test image signals, namely in each respective cluster of three corresponding images:

- cluster 01 – test images: 002, 006, 007;
- cluster 02 – test images: 004, 010, 012;
- cluster 03 – test images: 003, 009, 011;
- cluster 04 – test images: 001, 005, 008.

D. Set for Clustering

To carry out the process of clustering it was generated set of images, including 4 types of signals: rectangular, sawtooth, harmonic and complex structure signal. It is assumed that the neural network will distribute signals to 4 clusters, and to the 4th cluster will include complex signals, the image of which for the given neural network will be "unknown" and the network will not to compare them with previous three types of signals, and allocates them to the new cluster. Fig. 4 shows set of 15 signals.

The testing process will be considered successful if the neural network will distribute these 15 images on a 4 cluster, given the recommendations that have been developed in the generation of signal images:

- cluster 01 – images: 001, 002, 003, 004;
- cluster 02 – images: 005, 006, 007, 008;
- cluster 03 – images: 009, 010, 011, 012;
- cluster 04 – images: 013, 014, 015.

IV. THE ARCHITECTURE OF THE NEURAL NETWORK

A. The Structure of the Neural Network at the Training Stage

In the training stage of development of the neural network on its inputs was supplied training set, which consisted of 14 images (Fig. 2). The first layer of the neural network consisted of 20 neurons and in the second layer were four neurons.

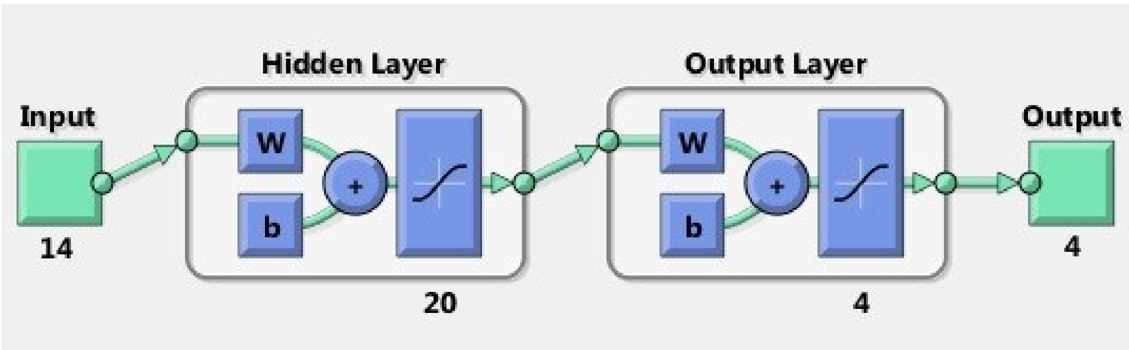

Fig. 5 The architecture of the neural network at the training stage

At the output, respectively, signal images distributed into 4 clusters. This quantitative distribution of neurons in two layers due to the number of input data and amount of output data and has had an enormous impact on the primary structure of the neural network. Fig. 5 shows the primary structure of the neural network.

B. The Structure of the Neural Network at the Testing Stage

During the testing phase of the neural network at its inputs it was fed the test set of signal images comprising 12 elements (Fig. 3). The number of neurons in first and second layers remains the same as in the training stage and is equal to 20 and 4, respectively. The number of clusters is 4. Number of inputs is 12 images. The structure of the neural network at this stage is as follows (Fig. 6).

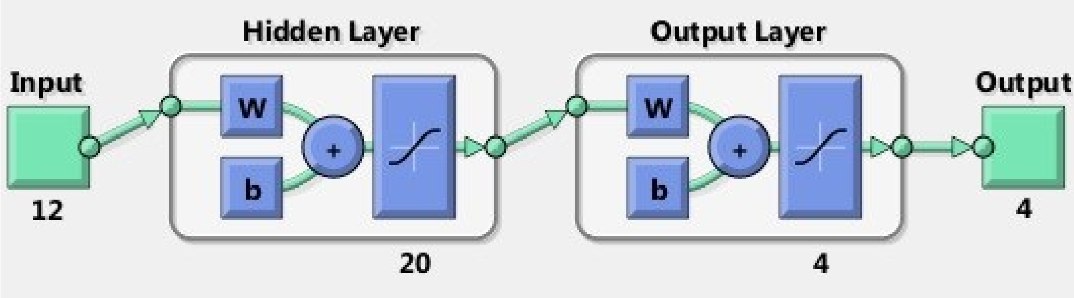

Fig. 6 The architecture of the neural network at the testing stage

C. The Structure of the Neural Network at the Stage of Clustering

After processing the results of the neural network and increase its reliability, by adding neurons to the first layer, it changed the structure of the neural network. The number of neurons in the first (input) layer increased to 25 neurons. In the second (output) has remained the same - 4.

The input of the neural network received 15 elements of the cluster set signal images (Fig. 4). The structure of the neural network at this stage of implementation is shown in the fig. 7.

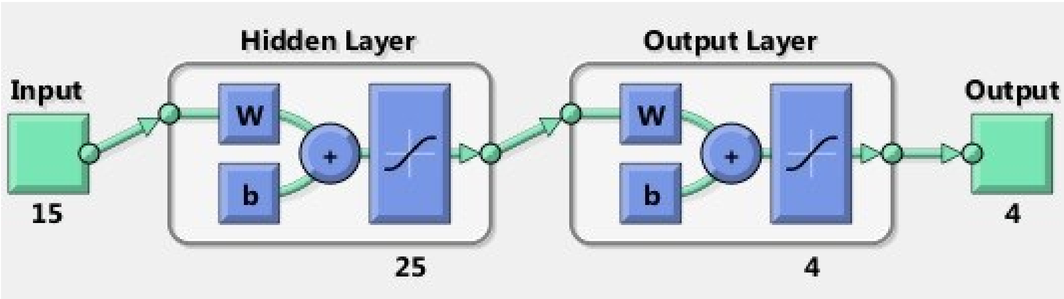

Fig. 7 Architecture of reliable neural network at the stage of clustering

V. OUTPUT DATA

Output data, which were obtained as a result of the testing process and process of clustering are fully confirmed serviceability and correctness of the established neural network. It confirmed by the expected distribution of the signal images relevant to intended result clusters in steps (processes) of testing and clustering.

Data are shown in graphs (images) of the structure and number of clusters, as well as responses at the command prompt MatLab.

A. The Test Results of the Neural Network

The test data set includes 12 images with signals of a harmonic type (Fig. 3), which were generated in the applied mathematical package MathCad15. When it created a set of signals a half of them were exposed to noise. An expected distribution of clusters is as follows:

- cluster 01 test images: 002, 006, 007;
- cluster 02 test images: 004, 010, 012;
- cluster 03 test images: 003, 009, 011;
- cluster 04 test images: 001, 005, 008.

Results of distributions obtained during testing are presented in Fig. 8 – 9 .

Fig. 8 shows that the neural network for the distribution of a set identified 4 clusters, each of which has put on 3 objects (images), which corresponded to the anticipated results.

Fig. 9 shows a response of the neural network as function comprising two parameters: the cluster number (h) and the image number (p), which included to this cluster.

Based on the results shown in Fig. 8 - 9 and the expected results in the preparation of the test data set, you can draw the following conclusion: the neural network implemented clustering of the test data set in accordance with the proposed distribution.

Having regard the fact that the proposed results and the obtained results when testing the neural network are identical, it is worth noting that the results of the test confirm the operation and readiness the neural network to implement further clustering process.

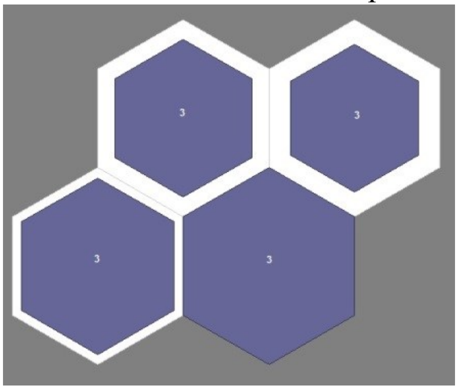

Fig. 8 The graph of images distribution in clusters

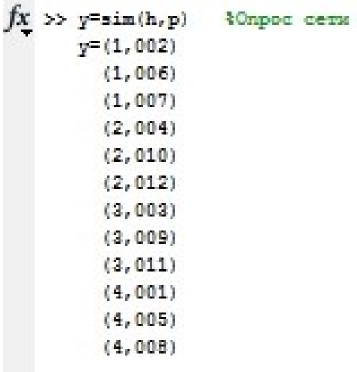

Fig. 9 Numerical test results presented in the command window

B. The Results of Clustering Signals

The data set for clustering process include 15 signal images (Fig. 4). It includes 4 types of signals: rectangular, sawtooth, harmonic and signals with complex structures that were generated in the applied mathematical package MathCad15. When it created a set of signals a half of them were exposed to noise. An expected distribution of clusters is as follows:

- cluster 01 images: 001, 002, 003, 004;
- cluster 02 images: 005, 006, 007, 008;
- cluster 03 images: 009, 010, 011, 012;
- cluster 04 images: 013, 014, 015.

The results of distributions obtained during the process of clustering, are presented in Fig. 10, 11.

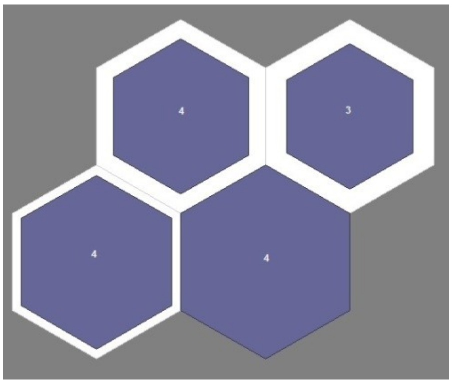

Fig. 10 The graph of images distribution in clusters

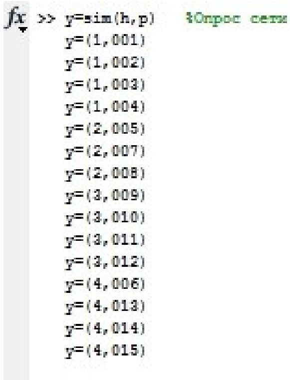

Fig. 11 Numerical results of clustering represented in the command window

Fig. 10 shows that the neural network for the set distribution identified 4 clusters, in 3 of which are placed on 4 objects (images), and the rest 3 objects that does not quite match the intended results.

Fig. 11 shows the response of the neural network as a function of having two parameters: the cluster number (h) and the image number (p), included in this cluster.

Based on the results shown in Fig. 10, 11 and expected results in the preparation of the clustered data set it can conclude the following: the neural network implemented clustering of data set with an error regarding the proposed distribution. The error lies in the definition of image 006 to the cluster 04. As the element 006 is the image of sawtooth signal, the neural network was supposed to define it to cluster 02.

Taking into account the good results of clustering signals and made a small mistake, it is advisable to increase the reliability of the developed neural network, thereby to improve the accuracy and quality of its operation (clusterization).

C. Results of Clustering Signals by the Neural Network with High Reliability

To ensure the correctness and adequacy of the conclusions about the quality of clustering when comparing results of the distribution to clusters of data processed by upgraded and primary neural networks, it is advisable to use the same set of signal images which includes four types of signals: rectangular, sawtooth, harmonic and signals with complex structure. The total number of images is 15 (Fig. 4). An expected distribution of clusters is following:

- cluster 01 images: 001, 002, 003, 004;
- cluster 02 images: 005, 006, 007, 008;
- cluster 03 images: 009, 010, 011, 012;
- cluster 04 images: 013, 014, 015.

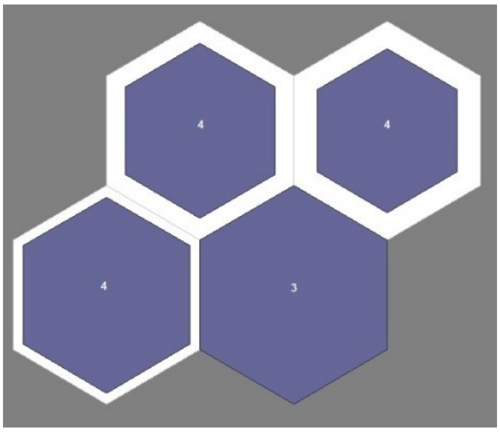

Fig. 12 The graph of images distribution in clusters

Fig. 13 Numerical results of clustering represented in the command window

Results of the distribution obtained by carrying out the clustering process are shown in Fig. 12, 13.

Fig. 12 shows that the neural network with high reliability for the set distribution identified 4 clusters, in 3 of which are placed on 4 objects (images), and to the last cluster it distributed 3 objects that corresponded to the intended results.

Fig. 13 shows the response of the neural network as a function of having two parameters: the cluster number (h) and the image number (p), included to this cluster.

Based on the results shown in Fig. 12, 13 and expected results in the preparation of the clustered data set it can conclude the following: neural network implemented clustering of data set without error, with respect to the alleged distribution. Upgraded neural network with higher reliability determined image 006 to the cluster 02, which contained the ramps. Fig. 13 displays images which presence at the sawtooth cluster (cluster 2).

Considering that the estimated and the obtained results by the clustering are identical, it is worth noting that the neural network with high reliability successfully complete the task, thus confirmed its efficiency and readiness for implementation of the quality distribution of similar signal images into classes.

VI. CONCLUSIONS

The studies proposed a complex approach to improve the reliability of the neural network, which has allowed to provide for the established network high standards of efficiency and performance. Using an integrated approach of classification process of the input data stream it was no error, while using the traditional approach has been fixed misclassification object. It leads to make the conclusion about the effectiveness of the proposed method.

As the software development environment of the neural network used the application of mathematical package Matlab 7.11.0.584 (R2010). To generate test sets of images of various signals used Applied mathematical package MathCad 15.0 (15.0.0.436 [006,041,742]). Software ran by the operating system Windows 7.

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