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QUANTIFICATION OF ENVIRONMENTAL ASPECTS

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Abstract:*Aspects of environment represent a complex field and also one of the most demanding articles of standard considering that efficiency of environmental protection management depends exactly on substantial and fundamental respect of this request. The contribution of this paper is directed towards environmental aspects quantification phase where new method based on neural network was initiated. The method should provide sufficient objectiveness and accuracy in assessment of environmental impacts for all types of organization and it is based upon the specificity of available mathematical models used by certified organizations in SCG.*

Keywords: environmental**,** aspect, impact, artificial neural network, quantification

1. INTRODUCTION

Aspects and impacts on environment represent the most significant request of the standard and procedure of environmental protection in general, where further compliance with requests of the standard does not lead to the complete fulfillment of assigned goals, if it is not defined in details at this point, and in that way the whole work on environmental protection of one organization can be put in question.

Aspects of environment represent a complex field and also one of the most demanding articles of standard considering that efficiency of environmental protection management depends exactly on substantial and fundamental respect of this request. Most of key articles are based on knowledge of significant environmental aspects while other standard articles stand in certain correlation with them although they do not entirely dependent on them.

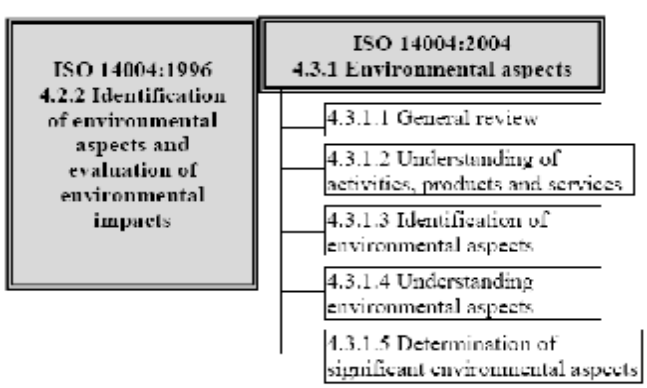

Figure 1. Structure fact "Environmental aspects" in standards ISO 14004:1996 and ISO 14004:2004

This topic was elaborated in both versions of standard (ISO 14001:1996 and ISO 14001:2004) under the same title "Environmental aspects" and the same article 4.3.1. As for standard ISO 14004, difference is obvious because ISO 14004:2004 goes more in-depth with identification processes and significance of aspects and environmental impacts. The fact that 5 sub-articles were formulated within the article "Environmental aspects" in ISO 14004:2004 where guidelines and recommendations had been given, shows what value this new standard does attribute to this request (Figure 1). Through analysis of 4.3.1 and part of aspects' significance and environmental impacts evaluation in standard ISO 14004, too much freedom of choice left for organizations can be observed:

- metodology
- significance criterion
- criteria ranking
- limited values od significance

In accordance with this, neither certification institutions do not enter into evaluation methodology chosen by organization, but only analyze final results and evaluate way of monitoring and rehabilitation of significant aspects' consequences. This therefore leaves too much space for manipulation with data whereon entire system of environmental protection management is based and which should be determined as much as possible. Namely, based on the available data from three certified organizations (A, B and C) in SCG territory that are related to the chosen mathematical model and evaluations of environmental aspects, worrying declination in number of significant impacts can be seen dependent on the applied verified model and which can not be justified by different activities of organizations.

As to overcome stated non-uniformities of certain methodologies and yet to adopt their specificities and gained results, we approached production of program for evaluation of environmental impacts through application of neural network. Tending was to establish a model with as less as possible subjectivity in individual evaluation so as to avoid possible manipulations with results.

2. NEURAL NETWORK (FEED FORWARD BACKPROPAGATION)

Back-propagation neural network is most commonly applied in practice as for its simplicity as for the wide spectrum of problems it can solve (shapes recognition, robot and vehicles management, figures classification, knowledge processing and other different problems of shape analysis).
Feed forward Back-propagation neural network belongs to group of networks that have following characteristics:

- number of layers: multi-layer
- architecture: layered
- training: statically supervised
- direction of information flow: non-recurrent
- kind of data: discrete static

Back-propagation is abbreviation from "back error propagation" which is translated as propagation of error backwards. It is a network with two or more layers, therefore it has at least 1 hidden layer and most commonly networks with completely linked layers are used (Figure 2)

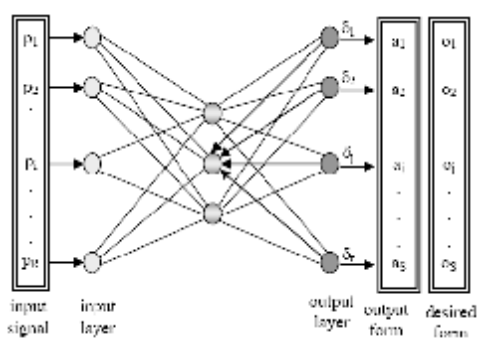

Figure 2. Two propagation steps of back-propagation neural network

Back-propagation neural network has two phases in the procedure of training, as follows:

- phase (propagation) forward and
- phase (propagation) backward

During first propagation (forward), computation of all neuron responses is performed starting from the first till the last layer based on input signals that are presented to network. All weight coefficients are calculated during this phase.

Second propagation (backward) implies correction of weight coefficients based on calculated error that is gained as a difference between a real and desired response. This phase is finished only when correction of weight coefficients for all neurons in all layers is done.

Statically supervised training of back-propagation neural network is represented in Figure 3.

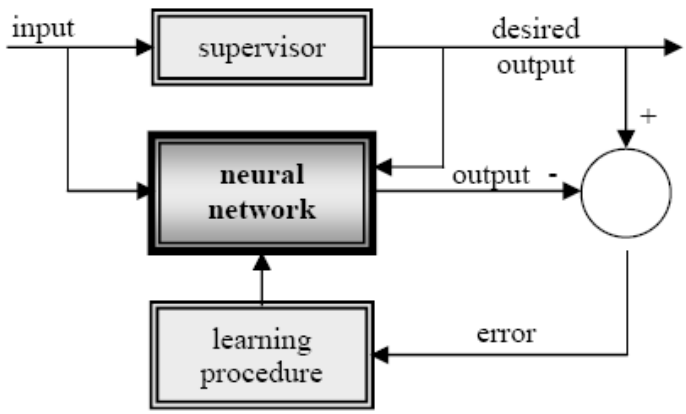

Figure 3. Supervised (offline) learning

After we get a trained neural network, testing of model by simulation (test) sample can begin.

Software package Matlab has been used in the concrete example for neural networks training.

Growing presence of Matlab in different university centers and scientific-research institutes is consequence of simple approach to programming i.e. possibility of work in the environment, which is very suitable for resolving concrete problems by application of simple notation. Abrupt upward trend of this software package has been realized by development of possibilities to add on the modular type i.e. development of additional modules, so called

Toolboxes which supplement Matlab "by functions which are interesting for certain mathematic and engineering disciplines". One of the moduls is also Neural Network Toolbox, which encompasses functions for neural networks designing and simulation.

For feed - forward back-propagation network type in Matlab software package it is possible to chose following parameters:

1. Training function
2. Adoption learning function
3. Network performance function
4. Number of neuron layer
5. Number of neurons in layer
6. Transfer function

within a window "Create New Network" represented in Figure 4.

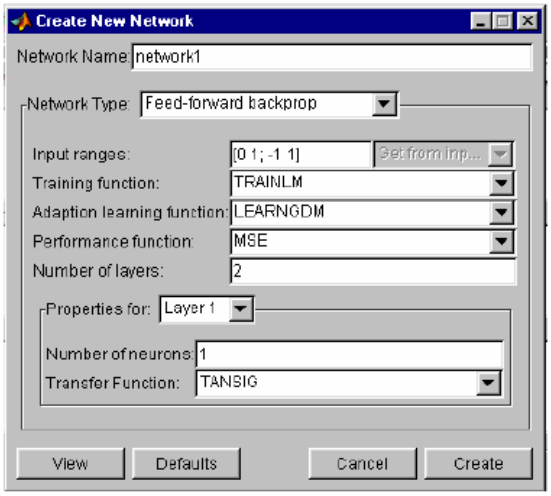

Figure 4.Choice of back-propagation neural network performances

Choice of the training function is of great significance for providing the speed of learning the given network i.e. algorithm. It is difficult to answer in advance which function shall give the best results for the given problem because there are several factors on which it depends (number of training samples of the training set, expected accuracy, number of neurons in the network,…)
Trainlm network training function which updates weight and bias values according to Lovenberg-Marquardt optimization gave the best results as regards the concrete problem.

Immediately following the training function selection it is placed at user's disposal to select an adoption learning function which is related to the manner of calculation of weight coefficients change, and which can have a big impact on the speed of convergence and size of error for certain network and training function selection.

3. PROBLEM ANALYSIS

Taking into account that there is a very small number of certified organizations in the territory of Serbia and Montenegro in accordance with the standard ISO 14000 (28 totally) the first idea was to create a neural network on the basis of due diligence from all the organizations, which would be trained to evaluate significance of the impact in the new organization on the basis of such a great number of input – output information and different mathematic models.

However, due to impossibility of cooperation with a larger number of organizations, data from 4 organizations were collected, so the training of neural work was performed on the basis of data from 3 organizations (2184 impacts which classifications are presented on figure 5) and data from the fourth organization were used for simulation of the model.

Impression can be received that three organizations are insufficient for such an analysis, but still the number of 2184 impacts could be more than sufficient to determine certain regularities and possibilities for application of neural networks or some other ICTs in this problem area.

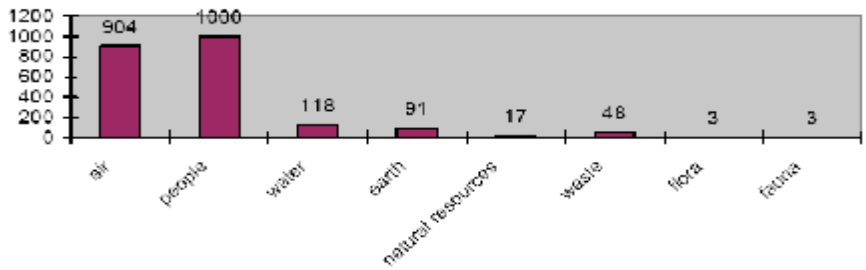

Figure 5. Diagram of impacts number division according to the mediums of effect

Having in mind that in the course of due diligence from the certified organizations, which fields of activities are completely different, they bound themselves to respect the principle of "absolute discretion" and not to use any names or any organization\s identity anywhere, we shall use in the following text the signs A, B and C for organizations, and the data will be analyzed to work out the new model, and D shall be the sign for the organization which data shall be used for simulation of work of the model.

The neural network model was training for all mediums of effects except for flora, fauna, waste and natural resources because the number of data in relation to flora, fauna and natural resources is very small and as regards waste it is obtained from only one organization. Therefore, these impacts were not further considered, due to impossibility to obtain real results.

In this paper we will show details about results for medium air, and in conclusion we will obnserve all results.

4. FEED FORWARD BACK-PROPAGATION NEURAL NETWORK (MEDIUM AIR)

As evaluations for all the three organizations (A, B and C) were obtained on the basis of different methodologies (mathematic models) it is necessary to perform normalization of input data in relation to the organization with the highest range of evaluations in order to harmonize evaluation differences. The biggest range of evaluations is in the organization A in relation to the criterion "Environmental Impact Volume", so that the evaluation is taken as maximum also for other organizations, and the relation of evaluations among the criteria within the organizations, characteristic for its own mathematic model aimed at preservation of their particular quality, is kept in this process.

For medium air, 904 inputs were gained that had been normalized before their input into neural network according to organization with the biggest span of marks, and care was taken that relations between criteria within every model were kept so not to disturb their own character. Network outputs (final evaluation of the impact significance) were normalized in relation to limits preset through the Matlab software package and which are related to the allowed output width (-1, 1) so all significant impacts according to own mathematical models were evaluated by evaluation 1 and those insignificant by evaluation –1.

The procedure which will be presented for medium air, for which 904 information i.e. inputs were obtained, is applied to other mediums except for flora, fauna, waste and natural resources because the number of data in relation to flora, fauna and natural resources is very small and as regards waste it is obtained from only one organization.

Appearance of the selected neural network for medium air with three layers out of which the first two have each nine neurons, and the last output according to the rule 1 is presented in the figure 6.

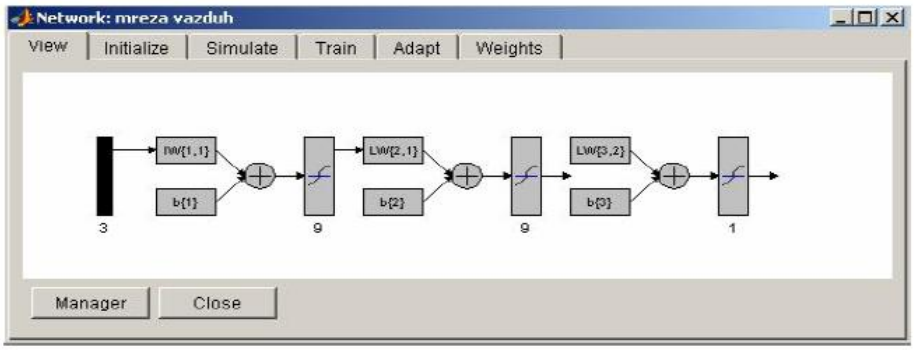

Figure 6. Appearance of neural network (air)

Performances of the chosen back-propagation neural network for medium air are given in Figure 7.a and its convergence diagram that defines a speed and accuracy of training in Figure 7.b

Figure 7.a Neural network performances

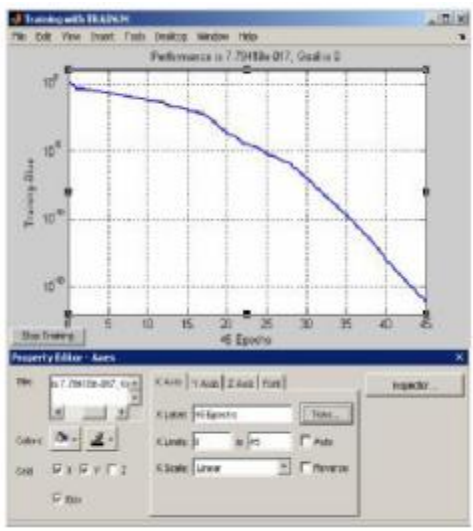

Figure 7.b Convergence of neural network

After results derived like this, with relatively fast convergence and high accuracy, model was tested with data from organization D and produced results that have completely coincided with mathematical model of organization D chosen from four available models to serve as a referent one. Appearance of basic window in Matlab with results of network training and simulation for medium air is given in Figure 8.

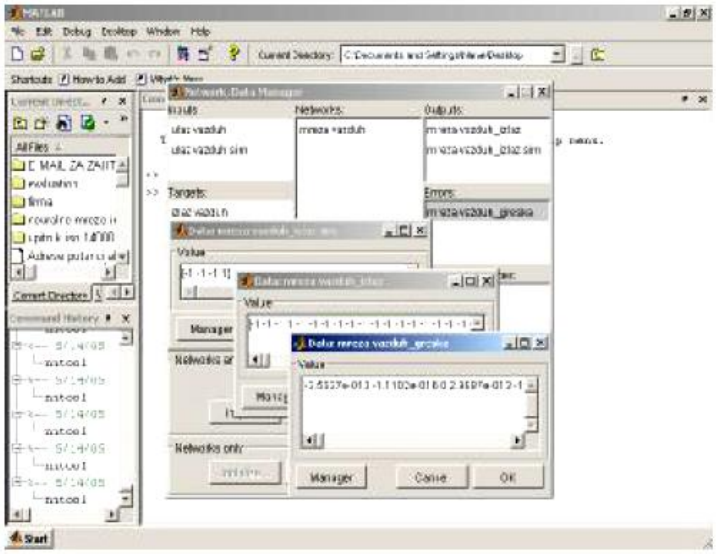

Figure 8. Appearance of basic window with results of network training and simulation (air)

Procedure was repeated also for medium people where great coincidence of results has also appeared (in great deal) with model of organization D. Results for mediums water and land were not satisfied because a small training sample.

5. CONCLUSION

Comparative analysis of available mathematical models and obtained results through application of neural network has ascertained that the chosen back-propagation neural network had given satisfying results for sufficiently large training sample as it was for medium air and people. We can see (figure 9) that for medium air we have got same results like mathematical model of organization D. For medium people we have little variance.

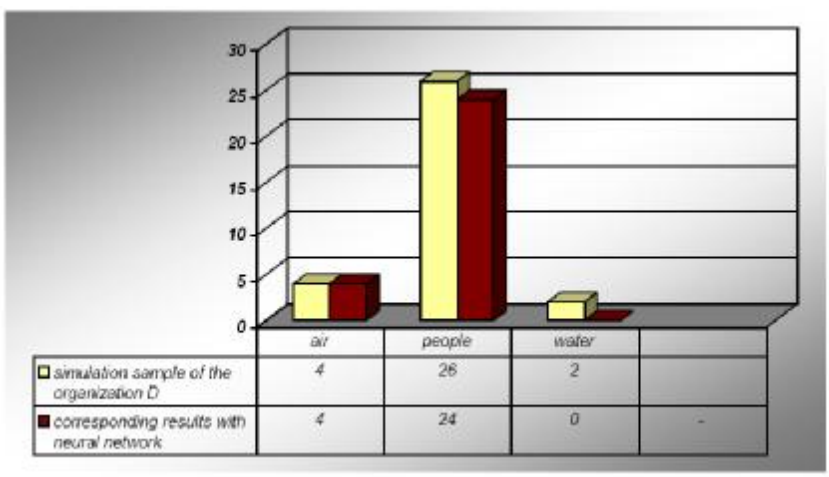

Figure 9. Comparative analysis of the neural networks model in comparison with the model of the organization D

The difference in the results obtained by the application of these two different models is for two impacts of medium people. However, by an analysis of the mathematic model of organization D it can be seen that these two impacts belong to the limiting value that is not included as significant for the given model while the neural network acquires these data as significant. Therefore, it can be realized that the neural network, as regards the influence on health, is more sensitive about the significance of impact than the mathematical model of the organization D, although the limiting values for each model as well as the neural network can be deemed as critical points due to the inexistence of recommendations of the standards or an exact analzsis for their determination.

Satisfying results for mediums water and land were not obtained exactly because of rather small training sample based on which network was not able to produce correct output. That is represented on figure 9.
The evident fact is, that evaluation like this that itself has incorporated specificities of available models from practice, has the highest character of objectivity and does not leave enough space for manipulations in the part of forming register of significant impacts and its efficiency and objectivity could be significantly improved through additional training of neural network with innovated data.

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