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e.co Investment Project Management Through Time Applying Artificial Neural Networks

Abstract: The concept of project management expresses an indispensable approach to imvestment projects. Time is often the most important factor in these projects. The artificial neural network is the paradigm of data processing, which is inspired by the one used by the biological brain, and it is used in numerous, different fields, among which is the project management. This research is oriented to application of artificial neural networks in managing time of investment project. The artificial neural networks are used to define the optimistic, the most probable and the pessimistic time in PERT method. The program package Matlab: Neural Network Toolbox is used in data simulation. The feed-forward backpropagation network is chosen

Keywords: project management, artificial neural network, PERT

1. INTRODUCTION

Modern organizations operate in an environment which is characterized by the global competition, rapid technological development, shorter lifetime of the products, scientific explosion, increased number of information, etc. The fact is that the complexity of business is still increasing. In order to react in time and to be efficient, an organization has to use the concept of project management as its new business philosophy.

The concept of project management is an indispensable approach in managing various projects, particularly investment projects, due to their high complexity, enormous costs, long duration, numerous participants in realisation and other parameters. The effects of application of this concept can be viewed in significant savings of time and finance, as well as in rationalizations in the process of project realisation.

The basic elements of realisation of any project that has to be planned, monitored and controlled are: time, resources and costs. Time

is often the most important factor in investment projects, because it influences costs, as well as the technological process. The PERT method time analysis is used in long-lasting investment projects, where the time duration of realisation creates significant uncertainty in future situations. Simulation in neural networks can be applied to determine the optimistic, the most probable and the pessimistic time, by applying the software package Matlab: Neural Network Toolbox.

2. PROJECT MANAGEMENT

The earliest forms of modern project management cam be found during the Industrial Revolution. The key protagonists who laid the foundation of the early project management were: Frederick Taylor, Henry Gantt and W. Edwards Deming. However, the project management that we know today, started with the development of the first methods of network planning, at the beginning of 1960s.

The appearance of personal computer and the project management software further improved the field of project management, and the corresponding methods and techniques expanded even more.

Starting from 1990s, the concept of project management is getting the forms that are being widely used and introduced as project realisation practice. One of the reasons for the development of project management concept and its increasing application is connected with the changes that happened in the preceding period. The enterprises started to introduce and adjust the management concept, as their way of carrying out the changes and improving the business process as a whole. Today, the projects are seen as the means of carrying out the organisation's strategy.
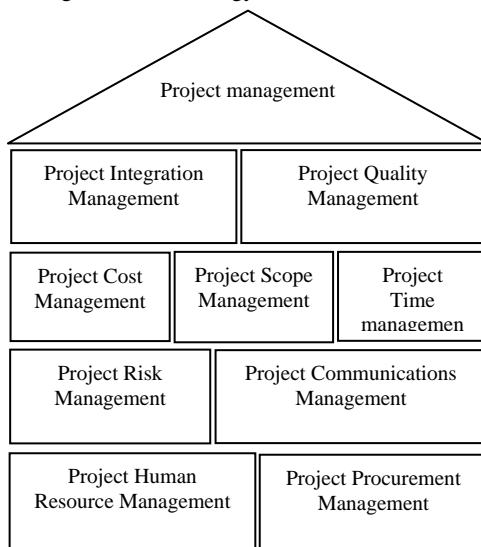

Figure 1. Basic knowledge in project management

The standardization in the process of project management is one of the main trends. The main active participants in the project management standardization are the professional associations, which created their own "Body of Knowledge", a document that is necessary for the profession defining and setting the criteria in project management. PMI (Project Management Institute), the American professional organisation, that is engaged in project management, suggests and applies the management concept based on the classification and examination of nine basic functional fields, shown in Figure 1, that make its theoretical

base and real possibilities for practical usage today.

The basic goal of realisation management of any project is to obtain reqired technical performances and the project quality with minimal time and costs of realisation. If the planned realisation time and costs can not be obtained, then the goal is to minimize the time and costs exceedings.

Investment projects contain the following characteristics: they are long-lasting, there is a large number of participants, numerous resources are involved, a great deal of financial resources are used, they are very complex, there exists the realisation duration, the application of standard software is necessary, as well as monitoring and control of the realisation for a long time, etc. The planning of the realisation time of the investment project relies on network planning techniques. One of the techniques of network planning is PERT (Program Evaluation and Review Technique) method. It relies on stochastical approach and respects uncertainty of future and impossibility of defining the future situations and events equally and accurately.

3. ARTIFICIAL NEURAL NETWORKS

Artificial Neural Networks are relatively crude electronic models based on the neural structure of the brain. The brain basically learns from experience. As well as the biological neurons, the artificial neurons have simple structure and similar functions. Neuron accepts inputs, processes them and creates one output. While the biological neurons use synapses to regulate the pass of a certain path between axons and dendrites, the artificial neurons use adaptable weight. When certain values are brought to the neurons input, and then multiplied by weight, input data are created. Total neuron input value multiplied by certain weight is put through the activative function and the output neural value is created. Although neurons have rather simple functions, when joined in a multi-layer network, they are able to process very complex functions. Except weight, neurons also use the value "threshold" (bias) in hidden output layers to calculate network input values. Threshold is the value which can be treated as additional input weight with constant weight one. Figure 2 demonstrates parts of

T. Gvozdenović, M. Perović

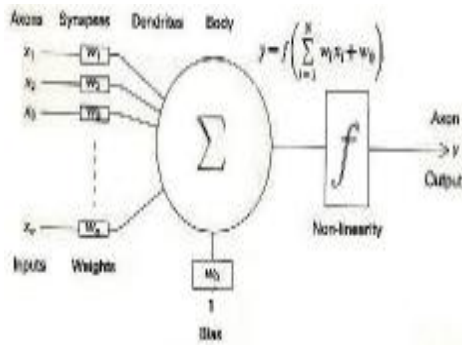biological neural networks in terms of artificial neural networks.

Figure 2. The role of biological neural networks in artificial neural networks [9]

The architecture of artificial neural network presents the specific structure and linking of neurons into network shape. Backpropagation, an algorithm, most used and relatively easy to implement, is used for neural network training (Figure 3). Backpropagation is the short form of back error propagation, which can be explained as error widening backward and it comes as a part of feed-forward network type.
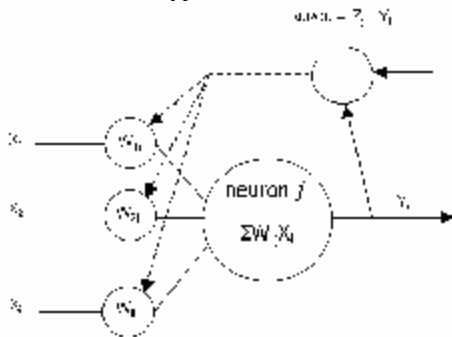

Figure 3. Backpropagation algorithm [7]

Comparing the output of neural network with the desired output, backpropagation reads the schemes and counts errors for each node in the network. Neural network adjusts the connection weights according to the error values, given to each node. Estimation starts from the output layer, follows through the hidden layers towards input layers. When parameters are modified, new inputs are brought into the network. The training is stopped only when the network is able to produce satisfactorily accurate outputs.

The algorithm procedure consists of the following steps [7]:
§ Weights initialization,
§ Creating input vector and desired output,
§ Putting the input vector through the network and getting total output,
§ Error estimation,
§ Weight adjustment backward from output layer towards hidden layers.

This is repeated for the whole set of output vectors, as long as the desired and the real inputs match, allowing for error toleration. A big network may need a lot time for the adjustment, so that a number of training iterations is given instead of toleration, in advance. The training time increases with each new hidden layer.

Neural networks are software applications that have to be programmed. Matlab is a software package, which consists of additional modules, called Toolboxes. One of them is Neural Network Toolbox which includes functions for projecting and simulation of neural networks. Neural Network Toolbox also includes graphic users interface for creating, managing, training and applying of certain neural networks.

4. APPLICATION OF ARTIFICIAL NEURAL NETWORKS

The construction of Hydro-technical Supply tunnel Fatnica Field – Reservoir Bileća is the integral part of the project "Upper Horizon's System" as a part of the unique multipurpose hydro system Trebišnjica. The tunnel Fatnica Field – Reservoir Bileća, is one of the key objects of hydro system Trebišnjica, that will enable efficient and economical usage of waters for purposes of energetics and water management, by transfering of water and connecting the Upper Horizon's with the part of the system which is already built [5]. Further development of the realisation of the project is conditioned by the finalizing of this tunnel. Due to its importance in terms of further investments, it is obvious that the factor of time has to be taken into special consideration.

As the completion time of certain activities can not be defined accurately, the PERT

method is used for time analysis. One part of data was obtained through expert estimation, while, the neural network simulation was appropriate to determine other data.

PERT method operates with three time values: the optimistic, the most probable and the pessimistic time, and according to them further analysis is done.

To determine optimistic, the most probable and pessimistic time we have used a simulation in program package Matlab: Neural Network Toolbox.

To carry out an experiment for training and testing the network, two parameters were used as an input: optimistic and the most probable time, while as an output parameter we used pessimistic time. Input data were obtained from the expert estimation. During the training of the network and in the framework of the software package Matlab: Neural Network Toolbox the following elements were changed:

- Network type.
- Network training function.
- Weight studying function.
- Performance function.
- Number of layers.
- Number of neurons in the layers.
- Transfer function.
- Number of epochs.
- Desired accuracy.

Feed-forward backpropagation network with parameters which are shown in Figure 4 has been chosen.
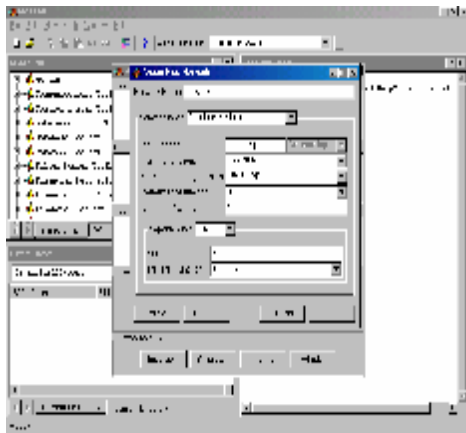

Figure 4. Feed-forward backpropagation network parameters

Matlab: Neutral Network Toolbox enables the application of the following transformation

functions:
- § PURELIN,
- § LOGSIG i
- § TANSIG.

The best results have been achieved (Figure 5):
- § using TANSIG function for the Layer 1 with 50 neurons and
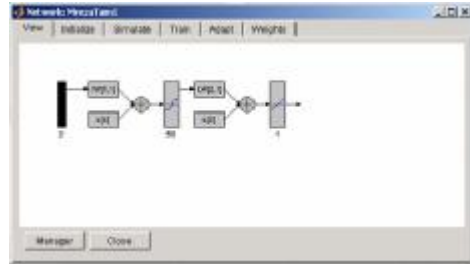- § using PURELIN function for the Layer 2 with 1 neuron.

Figure 5. Backpropagation Neural Network

Table 1 shows one part of data used for training and testing of neural networks, as well as obtained errors:

Table 1. Data, obtained by network training and testing

WBS	Input 1	Input 2	Output	Error
1.1.1.2	2,7	3	3,5	-0.0000
1.1.2.3	3,5	4	4	0.1750
1.2.1.1.2.2	1	1	1	-0.1667
1.2.1.2.1.2.4	0,8	1	1,1	0.0000
1.2.1.2.2.2.3	0,6	1	1,5	0.0000
1.2.1.2.2.2.7	1,9	2	2,4	0.3200
1.2.1.2.2.4.1	2,8	3	3,1	-0.4130
1.2.1.2.2.4.5	2,8	3	3,1	-0.4130
1.2.1.2.2.6.1	2,8	3	3,1	-0.4130
1.2.1.2.2.7	1,8	2	2,2	0.0500
1.2.1.2.3.2.3	2,5	3	3,5	-0.5000
1.2.1.2.3.3.2	3	4	4,2	0.0000
1.2.1.2.3.4.1	3,5	4	4,2	0.0250
1.2.1.2.3.4.4	3,5	4	4,2	0.0250
1.2.1.2.3.4.8	3,5	4	4,2	0.0250

1.2.1.2.3.4.11	3,5	4	4,2	0.0250
1.2.1.2.3.6.1	2,8	3	3,5	-0.0130
1.2.1.2.3.6.4	8	8,5	10	0.0000
1.2.1.2.3.7.2	2,8	3	3,5	-0.0130
1.2.1.2.3.9.3	2,8	3	3,5	-0.0130
1.2.1.2.3.10.1	2,8	3	3,5	-0.0130
1.2.1.2.3.10.3	2,8	3	3,5	-0.0130
1.2.1.2.5.2	1	1	1	-0.1667
2.1.2.6.2.2.3	1	1	1,5	0.3333
1.2.1.2.9.2	0,3	0,5	0,7	0.0000
1.2.1.2.11.2.2	1	1	1	-0.1667
1.2.1.2.12.2.4	1	1	1,5	0.3333
1.2.1.2.13.2	1	1	1	-0.1667
1.2.1.2.15.2.2	0,4	0,5	0,7	0.0000

The smallest errors have been obtained for 3903 epochs.

Trained network shown in Figure 4, served to obtain other one data for PERT analysis, as shown in Table 2.

Table 2. Simulated data for the PERT method

WBS	Simulated output	WBS	Simulated output
1.1.1.3	2.1833	1.1.1.4	3.5
1.2.1.2.2.2.1	1.1667	1.2.1.2.2.2.4	3.513
1.2.1.2.2.4.3	3.513	1.2.1.2.2.4.4	3.513
1.2.1.2.2.4.9	3.513	1.2.1.2.2.5	3.513
1.2.1.2.2.6.5	3.513	1.2.1.2.3.2.2	0.35638
1.2.1.2.3.4.3	4.175	1.2.1.2.3.4.5	4.175
1.2.1.2.3.4.12	4.175	1.2.1.2.3.6.3	10
1.2.1.2.1.2.2	1.1	1.2.1.2.1.2.3	1.1
1.2.1.2.2.2.5	2.08	1.2.1.2.2.2.8	3.513
1.2.1.2.2.4.6	3.513	1.2.1.2.2.4.7	3.513
1.2.1.2.2.6.2	3.513	1.2.1.2.2.6.4	3.513
1.2.1.2.3.3.1	4.2	1.2.1.2.3.3.3	4.2
1.2.1.2.3.4.7	4.175	1.2.1.2.3.4.10	4.175
1.2.1.2.3.7.3	3.513	1.2.1.2.3.8	3.513

In this way, all the necessary data were obtained for PERT analysis, which was further processed in program package Microsoft Project 2002. The analysis presented, estimated time duration of certain activities, as well as of the project as a whole. The critical path, which was obtained through time calculation applying artificial neural networks and PERT method, confirmed itself in practice while managing the project of construction of Hydro-technical Supply tunnel Fatnica Field – Reservoir Bileća.

5. CONCLUSION

Projects and project management are becoming a significant component in terms of business today. Time is one of the basic criteria to estimate the investment project's degree of performance. Software package Matlab: Neural Network Toolbox was used to solve the problems of calculating time in PERT method. On the basis of data obtained in expert estimation, the training and testing of neural network, with two inputs and one output was performed. Two parameters were used for input: the optimistic and the most probable time, while the pessimistic time was used for the output value. The trained network was applied to simulate the other data, which were necessary in PERT method. The obtained data served to calculate time with PERT method. The construction project of Hydro-technical Supply tunnel Fatnica Field - Reservoir Bileća, confirmed in practice that the application of project management concept is nesessary when efficient realization of investment project is needed.

REFERENCES:

[1] ANSI/PMI 99-001-2000 Project Management Institute.: "*A Guide to the Project Management Body of Knowledge (PMBOK)*", Inc Pennsylvania, 2000, USA

[2] Demuth H., and Beale M.: "*Neural Network Toolbox – For Use with Matlab*", The MathWorks, 2000

[3]   Gray F. C., and Larson W. E.: "*Project Management – The Managerial Process*", Oregon State University 2000.
[4]   Gvozdenović T.: "*Project management brought time in CIPR/CIE ambient's*", M.Sc thesis, Production and management faculty, 2004, Trebinje
[5]   PSC ERS, HPP on the Trebišnjica river: "*Feasibility stydy – Completion of stage I in construction of the Supply tunnel Fatnica Field – Reservoir Bileća*", Energoprojekt–Hidroinženjering, 1998, Belgrade
[6]   Jovanović P.: "*Project management*", Grafoslog, 2002, Belgrade
[7]   Lojanica V.: "*Graduation thesis – Artificial neural networks*", FON, 2001, Belgrade
[8]   Perović M.: "*Management - Informatics - Quality*", CIM Center, 2003, Kragujevac
[9]   Tim L.: "*Neural Network The Solution To True AI*", http://home.ipoline.com/~timlin/neural

T. Gvozdenović, M. Perović