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Calculation of Concrete Minarets Frequency by Neural Network

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Abstract: Determination of natural angular frequency of concrete minarets by artificial neural network with various supporting conditions is general goal of this research. For the subject of neural network, training or learning algorithms are applied .The most famous of network structure which is back propagation algorithm is applied in this study. This algorithm is a systematic method for training multi layer artificial neural network. Back propagation algorithm is based on gradient descant which means that it moves downward on the error declination and regulates the weights for the minimum error. In this research, the real frequency of concrete minarets is calculated first using SAP2000 program and is defined as a goal function for neural network, so that all outputs of the network can be compared to this function and the corresponding error can be calculated and so the best function will selected. Then, a set of inputs including dimensions or specifications of arches are made using MATLAB program. After the determination of algorithm and quantification of the network, the phases of training and testing of the results are carried out and the output of the network is created. It is concluded that the performance of the neural network is optimum and the errors are less than 8%, so, the network trains in different manner. Furthermore the time of frequency calculations in neural network is less than real analysis time that calculated by SAP2000 software and its precision is acceptable (less than 12%).

Key words: Artificial intelligence, excitement function, training function, learning function, MATLAB software

INTRODUCTION

Providing a program to answer to multivariate problem as input and output is hard or impossible because we can not consider all of variables and their effects on each other. Therefore, getting to know the artificial neural network and use of software can help to answer this problem .Also modern programming methods are the methods which are sensitive to error in input data but in artificial neural network, the training is on the base of experience and it can tolerate against errors (Grandhi, 1993). Artificial neural networks are used in different researching fields and professions and had prepared by cooperation of scientists in different fields such as computer engineering, electronic, structure and biology and so many different branches of science (Rodrigues *et al*., 2007; Remchaiswadi *et al*., 2003).

Previous studies of some researchers (Szewczyk and Hajela, 1993; Rajab and Al-Hindi, 2008) are the samples of approaching the best neural net work in this field. Some of the important usages of neural network are classification of data, recognition of letters and figures, estimation of functions and etc. (Vanderplaats and Thomas, 1993). Use of neural network in the structure engineering

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is developing and will develop more and more (Vanderplaats and Salajegheh, 1988). In the field of structure engineering, it used for optimization, analysis and designing, anticipate of results for soil and concrete, graphs theory and etc.

MATERIALS AND METHODS

The Concrete Minarets Which Used for Frequency Calculation

Calculating of plate frequency using the neural network in 2006, the researcher, developed their researches in the same field to gain the frequency of the other structures in different motion's modes. Selecting concrete minarets in this study, geometric modeling and also analyzing of different type of concrete minarets is done by SAP2000 software at the first step of this study (Fig. 1). It is assumed that the base support is fixed (it is fixed in all of directions). Meshing of minaret shell is calculated on the base of the best division state (meshing is divided to smallest parts and it is stopped in the state that the results remain fixed). By SAP2000 software, 10 minarets with certain specifications are studied and SHELL elements are shown. For calculation of concrete minaret frequency, three parameters (height, diameter and thickness) are used. The heights are 20, 30, 40, 50, 60, 70 and 80 m. The diameters are 2, 3, 4, 5, 6, 7 and 8 m and thicknesses are 0.2, 0.25, 0.3, 0.35, 0.4 and 0.45 m. For example a minaret with fixed ended is analyzed in three states:

- Minaret with fixed diameter and height and variable thickness
- Minaret with fixed diameter and thickness and variable height
- Minaret with fixed height and thickness and variable diameter

Making an Artificial Neural Network for Approximation of Concrete Minarets Frequency

For network training, at the next stage of the study, 300 concrete minarets with different height, diameter and thickness have been modeled. Each of concrete minarets has six parameters: length, diameter, thickness, Young's modulus, Poisson's ratio, density and concrete compressive stress. Three of them (length, diagonal, thickness) are based on concrete minarets dimensions and another (Young's modulus, Poisson's ratio, compressive stress and density) are based on concrete minarets quality. The alteration of concrete minarets length, thickness and diagonal are 20 to 80, 0.2 to 0.45 and 2 to 8 m, respectively. Changes of unit are according to decrease of input parameters dispersion.

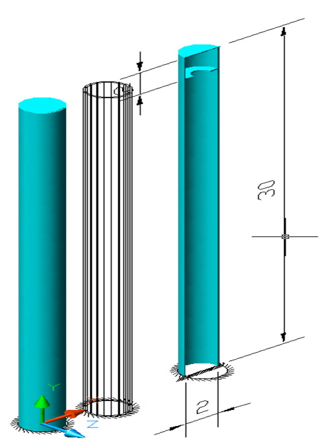

Fig. 1: Geometric properties of the supposed concrete minaret

Because the minarets are made of concrete, their quality coefficients are fixed. So, Young's modulus is 2.188×10^9 kg cm^{-2}, Poisson's ratio is 0.2, density is 2400 kg m^{-3} and concrete compressive stress is 210 kg. Because mapping range for input parameters should be 0 and 1, the units changes for decrease of dispersion in input parameter, so we consider micrometer, nanometer, μg h^3 for length, thickness and diameter, Young's modulus and density, respectively. Poisson's ratio is multiplied in 10^6. All of input parameters are divided to square of sum of square separately to network input mapping estimates among 0 to 1. All of results which obtained by concrete minarets analysis in SAP2000 software have been chosen as an objective function, to compare obtained output network with objective function and all errors has been calculated. In this formula:

$$\text{Net} = \text{NEWFF}\ (\text{PR},\ [S_1S_2\ldots S_i],\ \{TF_1TF_2\ldots TF_n\},\ \text{BTF})$$

Where:

PR	=	Matrix of R×2 with minimum and maximum input elements
si	=	The size of ith layer
Tfi	=	Excitation of ith layer(obtained by transfer function) with tansgin presupposition
BTF	=	Network conversion function with trainlm presupposition

Network specifications are defined by network structures, number of layers and number of neuron in each layer, transfer function in layers, learning function and performance evaluation (Fausset, 1994). Regarding to back propagation neural networks for concrete minarets frequency calculation, at first we should study NEWFF, NEWCF and NEWELM structure then choose the best of them. In this study, each of them is made separately and they have different layer (2-5 layers), so, the structure with less error is used for optimum network (Wasserman, 1989). For each structure 6 minarets have been tested and their specifications have been shown in Table 1. One of the test samples is part of training input and others are new inputs.

RESULTS AND DISCUSSION

The Study of NEWFF, NEWCF, NEWELM Neural Network

Because of studying of back propagation network in this study, different types of these networks structures, such as NEWFF (feed-forward back propagation network), NEWCF (cascade-forward back propagation network) and also NEWELM (element back propagation network), are studied and the best one is selected as bellow. Here, the neural network with 2-5 layers is studied in NEWFF structure. For each concrete minarets shape, 20 networks with different neurons analyzed.

Table 1: Dimensions of concrete minarets for network test

Concrete minarets sample	Dimensions (m) Thickness	Height	Diameter	Natural frequency (Hz)
1	0.20	25	2.5	16.26
2	0.25	35	3.5	22.19
3	0.30	45	4.5	22.86
4	0.35	55	5.5	34.46
5	0.40	65	6.5	36.27
6	0.45	75	7.5	38.11

Table 2: Results of neural network with 2-5 layers

	Two layer network		Three layer network		Four layer network		Five layer network	
Network	Test time ave.	Error (%) ave.	Test time ave.	Error (%) ave.	Test time ave.	Error (%) ave.	Test time ave.	Error (%) ave.
NEWFF	0.056	7.18	0.046	7.77	0.045	9.45	0.045	7.10
NEWCF	0.021	12.54	0.025	5.12	0.042	8.25	0.075	12.48
NEWELM	0.026	12.55	0.020	4.26	0.012	6.25	0.028	5.28

Modulus network had 6 fixed neurons in input layer concrete minaret variable parameters and one neuron in output layer (concrete minaret frequency). The neural network with NEWELM and NEWCF subroutine structure is also studied and results are given in Table 2.

Considering to NEWELM, NEWFF and NEWCF neural network output with 2 to 5 layers, it can be seen that under mathematical complex relations for regulation of interplay weight, we can not anticipated that by increase of layers, the network precision increases but we should get optimum network by trail and error test. After the tests, considering the obtained results in Table 2, it is determined that NEWELM neural network with 3 layers and error of 4.26% (which is the minimum calculated error between different presented cases in Table 2) has the best performance, so another stages will continue by this network.

Effect on Neuron Number (Neural Cell) in NEWELM Neural Network Layers

Neuron number is important in each layer, so if the number of layer is low, neural network can not reflect nonlinear mapping between input and output. On the other hand, if they are more than required, the network produces nonlinear mapping with unsatisfactory performance. Because neurons number are determined by trial and error test, so, NEWELM three layer neural network has been studied, separately. It's clear that three layer NEWELM neural network and 8 neurons in input layer and 8 neurons in the middle layer has less error.

The Effect of Excitement Functions in NEWELM Three Layer Neural Networks

Usually, network processes by excitement function and most of the time, is used as a logical or crescent (sigmoid). Although it's not necessary to choose excitation function for all neurons but the excitement function is same for neurons in layer and most of the time, nonlinear excitement function is used to maximize efficiency of multilayer networks. In this study, excitement functions such as purelin, logsig and tansig is back propagation algorithm that has been studied (Table 3).

In neural networks, inputs processes by excitement function and produces output. According to the results, the best function for the first, second and third hidden layer are tansig, logsig and purelin, respectively. The error is 2.12.

The Effect of Training Function on NEWELM Three Layer Neural Network

The goal of training is finding an optimum answer of network, so, that output gets from real answer. In network training, input and output vector couple with each other. Usually, a neural network trains with more couples. In neural network, primary weights are important. Before training the small weights are chose. We can not anticipated which training algorithm is better because this comparison is depended on different elements such as input data, weights number, goal error parameter and the aim of network usage.

In Table 4, the results of comparison between different training function in NEWELM network are shown. So, we found that Train OSS has less error (3.82%) and its performance is better than other functions.

The Effect of Learning Function on NEWELM Three Layer Neural Network

In the neural network, calculations are layer by layer, so, we can estimate outputs. At first, output of neural cells in a layer calculated and the result used as input for another layer. After that,

Table 3: Effect of excitation function in NEWELM three layer networks

Excitation function composition	Average error (%)	Average testing time (see)
Tansig-logsig-purelin	3.18	0.038
Tansig-Tansig-purelin	2.75	0.025
logsig-Tansig-purelin	2.12	0.024
Logsig-logsig-purelin	3.66	0.031

Table 4: Effect of training function

Kind of training function	Average error (%)	Average testing time (see)
Train LM	7.12	0.046
Train BFG	5.14	0.038
Train CGB	4.52	0.015
Train CGF	6.12	0.029
Train CGP	7.36	0.038
Train OSS	3.82	0.012
Train RP	8.25	0.025
Train SCG	5.11	0.044

Table 5: Effect of learning function

Kind of training function	Average error (%)	Average testing time (see)
Learn GDM	11.82	0.052
Learn GD	7.44	0.044
Learn SOM	5.25	0.033
Learn P	6.36	0.026
Learn OS	4.14	0.037
Learn l_{v1}	5.31	0.018
Learn l_{v2}	3.85	0.026
Learn CON	3.36	0.025
Learn K	4.50	0.043
Learn I_s	4.14	0.037
Learn H	3.11	0.025
Learn HD	7.26	0.014
Learn WH	6.64	0.033

Table 6: Effect of error function

Kind of training function	Average error (%)	Average testing time (see)
MAE	24.12	0.014
MSE	8.84	0.015
MSEREG	12.25	0.014
SSE	9.46	0.013

according to input, the second layer output is calculated. This process continues to output make output vector. Learning functions are important, so, the effect of learning function on NEWELM neural network is shown in Table 6.

According to Table 5, learn h function (error = 3.11%) has better performance. In this function, training input functions are binary. After training, the network gets continuous input and produces output.

The Effect of Performance Evaluation (Error) on NEWELM Three Layer Neural Network

In performance evaluation, we want to study how a network performs by trained and new (untrained) input. Amount of training and network performance has been calculated by different parameters and methods. Each of them has been studied separately and the best functions have been chosen (Table 6).

According the results, MSE function has the best performance.

By analysis, this neural network is suggested for calculation of minarets frequency:

NET= NEWELM (maxmin (p),[8 8 1],{'tansig' 'logsig' 'purelin'};'traincgb','learn p', 'MSE')

Network Testing for Concrete Minarets with Different Supports

Different concrete minarets have been analyzed by SAP2000 software and their real frequency has been determined. They tested by proposed network and their efficiency were determined by errors (Table 7, 8).

Table 7: Analysis of concrete minarets by f'c = 210, 250, 280, 350 kg cm^{-2}

Concrete minaret	Real frequency	Analysis time (see)	Network frequency	Training time (see)	Testing time (see)	Error (%)
f'c = 210 kg cm^{-2}						
1	18.17	0.95	19.46	8.46	0.038	4.46
2	22.45	1.18	12.23	12.17	0.068	3.85
3	23.51	2.45	12.22	12.54	0.025	2.54
4	16.20	3.71	17.10	13.20	0.018	¼
5	14.17	18.13	18.13	24.41	0.025	7.12
6	28.10	26.12	26.12	17.05	0.044	8.38
f'c = 250 kg cm^{-2}						
1	22.41	2.41	28.18	13.46	0.044	4.44
2	25.12	1.56	23.12	22.41	0.033	3.85
3	18.13	4.46	22.10	18.88	0.022	4.16
4	19.54	3.87	17.41	19.55	0.012	9.12
5	3.05	7.95	28.85	21.06	0.037	7.15
6	22.55	12.10	22.12	14.46	0.046	3.56
f'c = 280 kg cm^{-2}						
1	22.18	2.25	25.16	16.12	0.045	6.73
2	33.15	3.12	29.92	21.05	0.077	2.46
3	20.28	4.16	17.34	18.71	0.046	3.11
4	18.12	1.18	14.12	30.12	0.038	2.25
5	16.96	7.16	25.15	28.48	0.052	1.56
6	38.01	2.25	35.85	28.87	0.049	8.12
f'c = 350 kg cm^{-2}						
1	29.56	4.26	27.11	13.77	0.045	4.56
2	22.48	3.86	20.56	31.86	0.020	3.28
3	25.45	5.10	24.17	29.15	0.038	8.11
4	23.18	1.18	21.46	32.18	0.045	9.12
5	27.26	2.26	25.56	18.11	0.028	4.36
6	24.56	3.14	20.48	19.52	0.021	3.24

Table 8: The brief of analysis of different concrete minarets

Diagonal of concrete minaret	Average real analysis time (see)	Average testing time in network (see)	Average error (%)
f'c = 210 kg cm^{-2}	6.52	0.043	7.12
f'c = 250 kg cm^{-2}	7.58	0.038	8.16
f'c = 280 kg cm^{-2}	2.26	0.048	9.25
f'c = 350 kg cm^{-2}	9.46	0.025	6.46

Table 9: First and second frequency output for concrete minarets of f'c = 210 kg cm^{-2}

Concrete minarets	Real frequency	Analysis time (see)	Network frequency	Training time (see)	Testing time (see)	Error (%)
1	18.17	0.95	19.46	8.46	0.038	4.46
	16.14		17.12			4.12
2	2.45	1.18	22.12	12.17	0.068	3.85
	20.26		18.17			3.66
3	23.51	2.45	22.46	12.54	0.025	2.54
	22.10		20.28			2.26
4	16.20	3.71	17.10	13.2	0.018	1.40
	14.13		15.40			1.36
5	14.17	6.69	18.13	24.41	0.025	7.12
	13.50		12.86			6.66
6	28.10	10.12	26.12	17.05	0.044	8.38
	25.26		23.92			7.50

DISCUSSION

According to the mentioned points about the different minarets which are analyzed as before, following results are achieved. Being able to compare these different cases, the results are shown in Table 8-10.

Hitherto, according to different dimensions of concrete minarets, the first frequency output in neural network has been studied. Now, we study the first and second frequency output for

Table 10: The results of first and second frequency

Supports of concrete minarets	Average real analysis time (see)	Average testing time in network (see)	Average error (%)
Concrete minarets with diameter of 6 m	4.56	0.059	6.64

f'c = 210 kg cm^{-2} and the first to fifth frequency output for f'c = 280 kg cm^{-2} to calculated proposed network power for higher frequencies.

CONCLUSION

Regarding to complex mathematical relations for regulation of weights in neural network, we can not anticipated that increase of layers improve the network output. So, after the study of 2 to 5 layer network, three layer networks with NEWELM function has the best answer. Usually, network data processes by excitement function to neural output signal produce. According to change of structure functions the network output changes. With regard to effect of excitement functions combination in neural network, tansig, logsig and porelin are suitable for the first, second and third hidden layer, respectively. During network training, network weights converge, so with regard to input vector, the out put vector produced and network output convergence with goal function (real frequency) obtained by traincgf training function. Powerful network can answer to trained and new (untrained) input. It calculated by learning function and performance evaluation function, the training function (learn k) and performance evaluation function (MSE), are the best output for neural network. The research shows that kind of concrete minarets and their diagonals can not influence on final results of network. With change of diagonal in concrete minarets, the natural frequency obtains.

According to analysis, estimation of frequency with neural network is unlimited and outputs are accessible, but because structure elementary frequencies have more effects on dynamical analysis, they have been studied. With artificial neural network, structure neural frequencies are estimated rapidly and exactly (less than 10%). So, after network training, we don't need concrete minarets analysis.

REFERENCES

Al-Hindi, K.A., 2008. Analysis of Neural Network Edge Pattern Detectors in Terms of Domain Functions, Wseas Transactions on Information Science and Applications. 1st Edn., WSEAS Organization, Greece.

Fausset, L., 1994. Fundamental of Neural Networks. 1st Edn., Prentice Hall Company, New York.

Grandhi, R., 1993. Structural optimization with frequency constraints. A review. AIAAJ., 31: 2296-2303.

Remchaiswadi, N., W. Premchaiswadi, S. Duangpasuk and S. Narita, 2003. SMILE: Printed, Thai Character Recognition System, WSEAS Transactions on Information Science and Applications. 1st Edn., WSEAS organization, Greece, ISBN: 0-442-01310-8 .

Rodrigues, A., C. Iclar, D. Carlos, A. Bernardino and M. Minia, 2007. Hybrid approach to MK classification of stars neural networks and knowledge based system. 6th Wseas International Conference on Artificial Intelligence, Knowledge Engineering and Data Bases Corfu Island, Greece, February 16-19, World Scientific and Engineering Academy and Society, USA, pp: 110-118.

Szewczyk, Z. and P. Hajela, 1993. Neural network approximation in a simulated annealing, based optimal. Struct. Design, 5: 159-165.

Vanderplaats, G.N. and E. Salajegheh, 1988. An efficient approximation technique for frequency aonstraints in frame optimization. Int. J. Num. Meth. Engry, 26: 1057-1069.

Vanderplaats, G.N. and H.L. Thomas, 1993. An improved approximation for stress constraints in plate structures. Struct. Multidisciplinary Optimizat., 6: 1-6.

Wasserman, P.D., 1989. Neural Computing (Theory and Practice). 1st Edn., Van Nostrand Rrinhold, New York, ISBN: 0442-20743-3.