# Simulating peak ground acceleration by general regression and radial basis function and other neural networks in some regions of the world

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**Abstract**

Recording of ground motions with high amplitudes of acceleration and velocity play a key role for designing engineering projects.Here we try to represent a reasonable prediction of peak ground acceleration which may create more than 1g acceleration in different regions.

In this study, applying different structures of Neural Networks and using four key parameters , moment magnitude, rupture distance, site class , style of faulting which an earthquake may cause serious effects on a site. We introduced a Radial Basis Function Network(RBF) with mean error of $14\times10^{-3}$,as the best network for estimating the occurance probability of an earthquake with large value of PGA $\geq$1g in a region. Also the result of applying Back propagation feed forward neural network(FFBP) for predicting high value of PGA, with Mean error of $17\times10^{-3}$ , show a good coincidence with the result of the designed RBF Network.

**Keywords:**Peak ground acceleration, Moment magnitude, Rupture distance, site class, Radial basis function, General regression neural network,.

## 1. INTRODUCTION

Reviewing physical factors which influence ground motions is done by several authors and they are often applied in estimating ground motions. These group interpretations also are differentiated between source factors and site. Also, source parameters mentioned include balance of ground motions that contains specified factors of total amount of the energy released by resource like source intensity and specified parameter of rate of releasing energy. Also ground motion near fountain are influenced more powerfully by phenomenon close to fountain, therefore, works of near fountain like jump and guidance have special points.( Estrasser and Bommer, 2008).

Peak ground acceleration is one of the most important parameters which is often investigated in the studies related to earthquakes damages. They are mostly estimated by reduction relations and are expanded by analyzing data regression of powerful motions. In their article titled estimating reducing relations with neural networks, Mr, Hamza Gullu and Egrun Ercelebi investigated the way of applying neural networks in predicting peak ground acceleration using data of powerful motions in Turkey..(Hamza Gullu and Ergun Ercelebi, May, 2007).

In regression approach, PGA is repeatedly calculated as function of parameters of (earthquake magnitude, distance from source to system, general condition of system. Source characteristics and wave propagation). ( Douglas, 2003).

Comparing the correlation coefficient gained with neural network and regression, it can be concluded that neural network has higher level of coefficient. Also models of neural networks have weaker structures in the ability of generalization and always perceive effects of input parameters in predicting PGA.(relations 1and2).

$$R^n(M,M^n) \equiv \frac{Cov(M,M^n)}{\sqrt{Cov(M,M)Cov(M^n,M^n)}} \tag{1}$$

$$r = \frac{\sum_{i=1}^{m}(x_i-\bar{x})(y_i-\bar{y})}{\sqrt{\sum_{i=1}^{m}(x_i-\bar{x})^2\sum_{i=1}^{m}(y_i-\bar{y})^2}} \tag{2}$$

In relation (1) covariance matrix of magnitude of earthquake moment was used for sensors 2 , 3 and 4. Also estimating moment indicates a clear increase in time and number of censors. n also is number of timesteps related to censor number 1 ( Marne bouz et al, 2008).

In relation (2), $X_i$ is records and $\bar{X}$ is mean level. $Y_i$ is output estimated and $\bar{y}$ is the mean.(Krou and cha, 2002).

## 2. Methods and Calculations

One of the problems noticed by seismologists is occurring earthquakes in which peak acceleration of ground motion is unexpectedly more than 1g. Estrasser and Bommer (2009) used valuable data in such earthquakes and investigated physical process caused by them. PGA parameter is often estimated by reducing relations and analyzing regression. The first set of acceleration recorders investigated in the study of Estrasser and Bommer contain 44 horizontal components and 22 vertical ones in records of cases in which peak acceleration larger than 1g are estimated and correspond with 43 records gained from 40 stations during 26 earthquakes. In the first phase of neural network model, weight parameters are multiplied by their own corresponding input data and their scales are based on level of importance. After combining input of changing scale given with each other, the signal gained is lead to section in which transfer function is imposed on the signal. The output of this part is considered as a true output of neural network. Level of weights` coefficient and modifying them during training are regulated along with learning principles. Learning principles can be classified into two parts of supervised and unsupervised. In this research, 38records are considered for training the network and 8 records are considered for testing the network and 14records for training the network. Also a common network is created and from among several types of general feedforward network, Radial basis function and general regression we chose one of them. Also networks parameters is chosen which contains layers, number of neurons, rate of momentum , rate of learning , transfer function and maximum of repetitions and after that input display is specified. Then various networks are dealt with and regression charts, error square mean and momentum are investigated for each network as well. Finally, the least error mean is chosen among various networks and it will be considered as the best network. Relation (3) is used for normalization of 60 available records.

N=(X-Xmin)/(Xmax-Xmin)×0.8+0.1 (3)

The results of output and the error gained from three neural networks are considered in the results section.**3.**

**3.Discussion**

Three neural networks are introduced and investigated in this section.

3.1. General Regression Neural Network

The network was also invented by Donald Espect for modeling and recognizing the system and it can be considered as a generalization from probable neural network. Probable network is used particularly for classifying models, while general regression network has wider applications (figure 1,2 and figure 3).

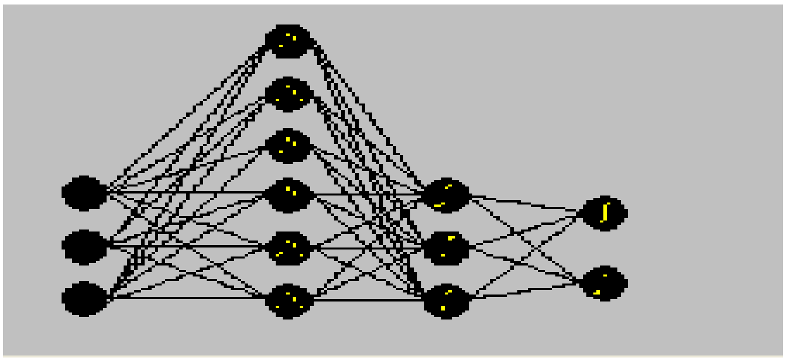

Figure1. Two layered feedforward network designed. The first hidden layer which contains 5 neurons and the second hidden layer which included 3 neurons are preceded. Function of transferring second and third layers are chosen by symmetrical Tanjong sigmoid and the last layer is usually considered linear and pure linear. Then the data and rules between all neurons are processed and they are not for special neurons. The connection between neurons has no direction and uses training rules of Lundberg Marcoart, descending gradient and feedforward back propagation such as other neural networks in order to train data of the network.

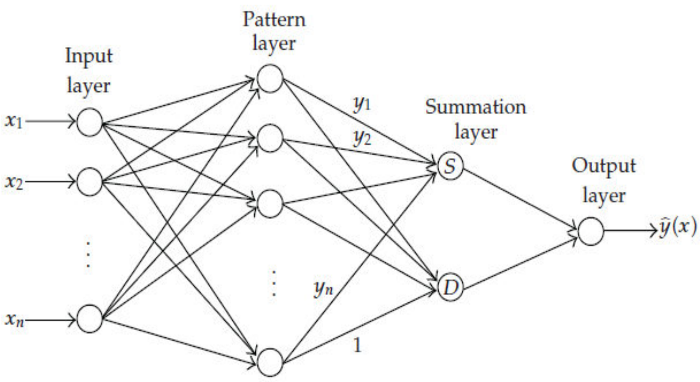


Figure2. General regression network designed. It can be observed that here we have four-layer network with two hidden layers. The first hidden layer has N neurons and the second one has 2 neurons and that neurons do calculation operations on input data and act as a processor.

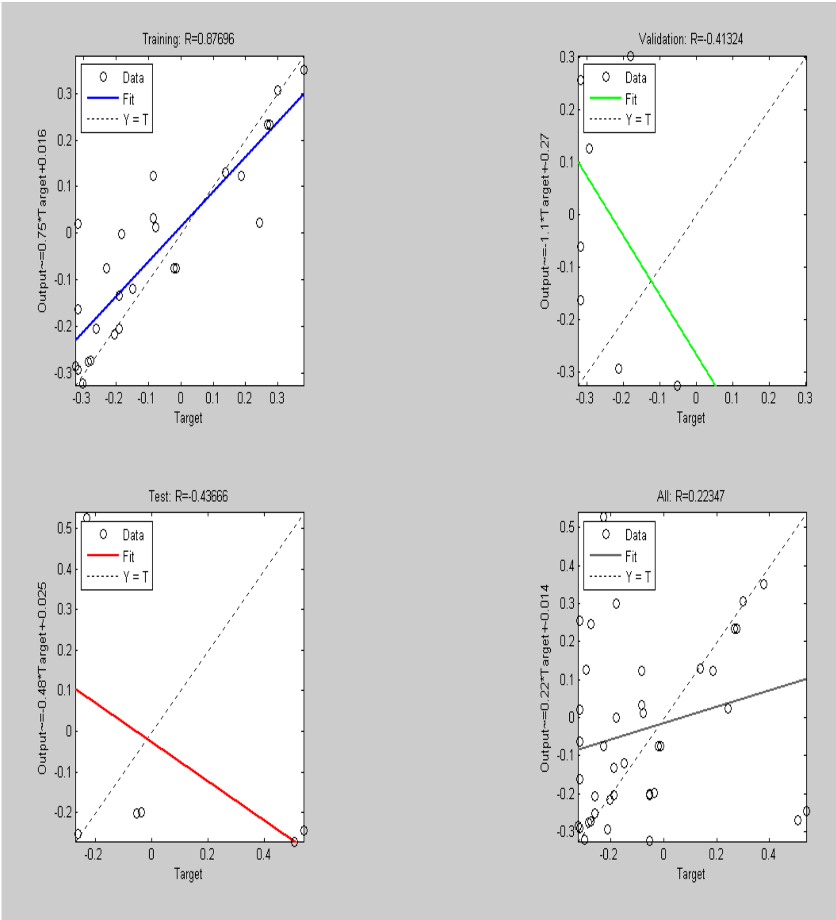


Figure3. Correlation coefficient stimulated for training steps , testing and examining general regression neural network by NN tool.It can be observed that training correlation coefficient is more that other ones and indicates that the network is trained well.

## 3.2. Radial Basis Function Network

Having verified applications, the network is one of the most desired neural networks and probably the real opponent of multi-layer perceptron. They are mostly inspired by traditional statistical model and these approaches were manifested in neural networks and are used widely.(figures 4and5).

Real architecture of RBF is a three-layer network. Input layer is a layer with splitting output and does not do any processing. The second layer or hidden layer does a nonlinear mapping from input space with a higher dimension in which patterns become separable in linear form, therefore, the final layers does a simple total weight with a linear output.

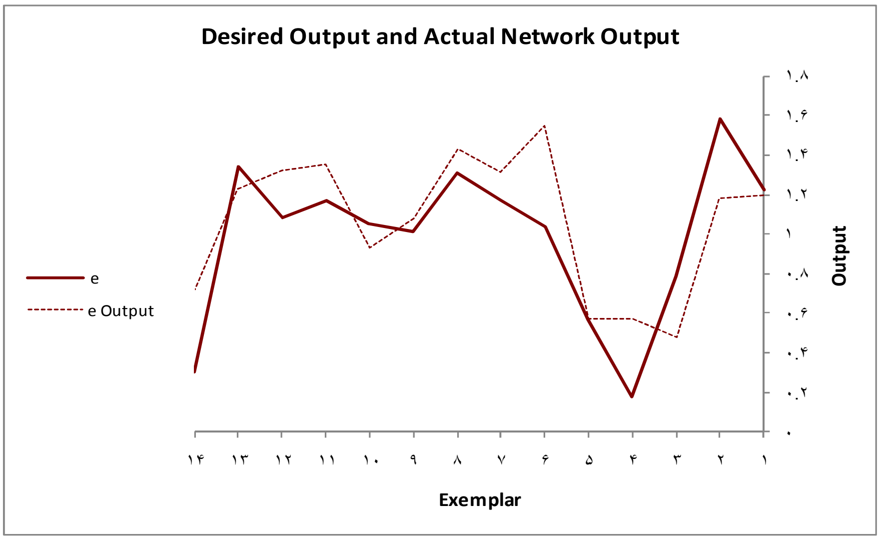


Figure5. Comparing real output with output of radios basis function network test designed. From the chart , it can be oncluded that the results of experimenting and the network were good and desired network is stimulated.

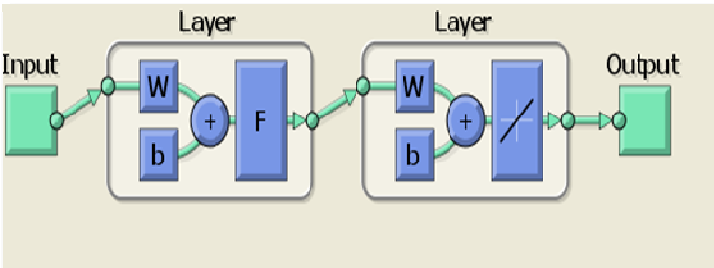


Figure 4. Radius basis function network designed. It is a four-layer network with two middle (hidden) layers which the first hidden layer has 6 neurons and the second one has 3 neurons and processing of data is done between them by the neurons. The first layer is in form of three-element column border and the last layer is in form of two-element column border. The last functions of transferring middle layer are usually chosen by log sigmoid.

## 4.Conclusion

To predict peak acceleration of powerful motion of the earth across different areas in the world, training data was used with the networks mentioned. The highest level of correlation coefficient for radius basis function network is equal with 0.67 and the least MSE is related to radius basis function network with error 0.014. The most MSE error is for general regression network with error of 0.071 and in the end output of testing the network for Fernando seismograph is equal to 1.24 which fits well with real output of 1.22.

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