FORECASTING OF LARGE PEAK GROUND ACCELERATION USING COACTIVE ANFIS and SVM NEURAL NETWORK

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ABSTRACT
Strong ground motions have important affects for the site,As a practical engineering design. specially accelerationStrong ground motions is one of the key factors in potential analysis the destruction is caused by earthquakes.
In this paper, to estimate maximum peak ground acceleration in an area, two artificial neural network was used, by name Coactive Anfisand Support vector machine neural network, In C-Anfis network ,Becausethe rules of fuzzy logic are combined with neural algorithms,OneStrong network with high flexibility can be resulted .
After different tests, Coactive ANFIS(C-ANFIS) network has maximum output correlation coefficient (0.82), Also has the least mean square error (LSSE=0.075).and SVM Network has maximum correlation coefficient (R=0.9955) and (LSSE=0.0014) .Therefore ,these two neural network aregood neural network which can estimate possible peak acceleration more than (1g) in an area.

Keywords: (Strong ground motions, engineering design , Coactive Anfis neural network,Leastmean sum square error , Support vector machine Neural Network).

1.INTRODUCTION
PGA is one of the most important parameters, often analyzed in studies related to damages caused by earthquakes (Gullo and Ercelebi, 2007). It is mostly estimated by the attenuation of equations and is developed by a regression analysis of powerful motion data.

Peak ground acceleration parameter is often estimated by the attenuation of relationships and also by using regression analysis.

One of the issues that seismologists are concerned about is the occurrence of earthquakes That is the maximum acceleration of the powerful ground motions in them,unexpectedlylarger than (1g). The first category of accelerographs in the study of Strasser and Bommer (2009) include 44 horizontal components and 11 componenets vertical records of the works are the maximum acceleration greater than (1g) are included.

Strasser et.al(2008) utilized by highly valuable data on such earthquakes and investigate the underlying physical processes.

In Coactive Anfis network,Becausethe rules of fuzzy logic are combined with neural algorithms, One Strong network with high flexibility can be resulted(Cartalopus 2003).The Support Vector Machine (SVM) is performed by applying the kernel Adatron algorithm. The kernel Adatron maps input to a high-dimensional feature space, and then optimally separate data into their respective classes.SVRs can be applied for regression analysis such as time series prediction, function approximation and etc.The aim of applying SVRs is to solve nonlinear regression estimation problems. These methods are referred to as support vector regression (Vapnik, 1995). Although SVRs were expanded to solve pattern recognition problems,

In another paper by Kamal and Aytengonaidine (2008) from three different types of neural networks used for estimating the maximum strong ground motions for earthquakes in northwestern Turkey.Of the 95 three-component records relating to 15 earthquakes, Between 1999 and 2001,The northwest of Turkey occurred ,Is used as input and output (target).

2.Methodologyand Results
In this research , we utilized two models of neural network . **1.**CoaciveAnfis Neural Network **2.** Support vector machine Neural Network.

2.1. Coactive Anfis neural network
In Coactive Anfis network, Because the rules of fuzzy logic are combined with neural algorithms, One Strong network with high flexibility can be resulted. The C-AnfisNetwork Compatible fuzzy inputs unifies until

complex functions with high speed and certitude estimated. Fuzzy inference systems , Hence combining the rules are important.

ANFIS is one of hybrid neuro-fuzzy inference expert systems and it works Takagi-Sugeno-type fuzzy inference system, which was developed by Jang (1993) . ANFIS has a similar structure to a multilayer feed forward neural network but the links in an ANFIS only demonstrate the flow direction of signals between nodes and no weights are related to the links (Nazmy, 2010) .

ANFIS architecture includes five layers of nodes. Out of the five layers, the first and the fourth layers consist adaptive nodes while the second, third and fifth layers consist fixed nodes (SeeFig.1). The adaptive nodes are associated with respective parameters, while the fixed nodes lack any parameters (Nazmy, 2009), (AbdulkabirSengur (2008)) .

ANFIS uses strategy of hybrid training algorithm to balance all parameters. It receives a given input/output data set and makes a fuzzy inference system whose membership function parameters are tuned, or adjusted, using a backpropagation algorithm in combination with a least squares type of method (Nazmy, 2009). Fuzzy inference systems are also known as fuzzy-rule-based systems, fuzzy models, fuzzy associative memories or fuzzy controllers when applied as controllers (Jang, 1993). Basically a fuzzy inference system is formed of five functional blocks (see Fig. 2).

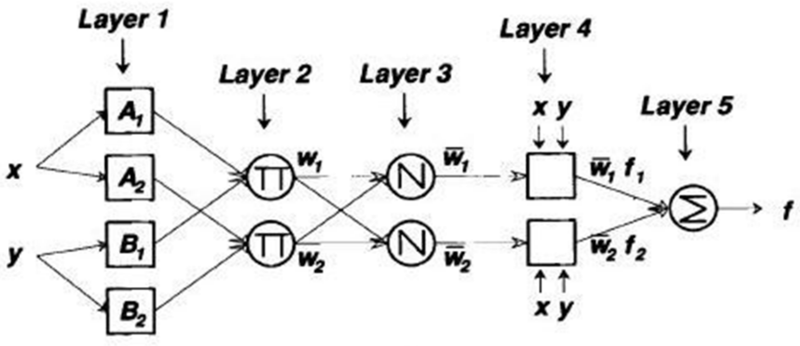

Figure 1. Adaptive Network Based Fuzzy Inference System Structure

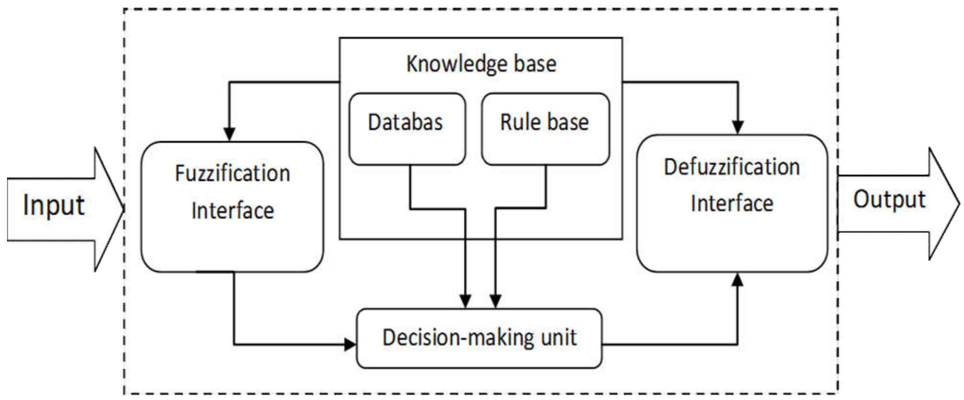

Figure 2 .Five functional blocks for Fuzzy Inference System.

2.2. C-Anfis Results and Data processing and SVM Results

The research is done for peak ground acceleration prediction by these two networks.The input space includes four parameters (Moment magnitude (Mw), Rupture Distance (RD), Fault Mechanism (FM) and Site Class (SC)) and output contains the components of PGA. It is used 100 records from different regions of the world that 70 records are used for training and 30 records for testing selected network.

The results of the error function and the coefficient of correlation obtained by the C-Anfis network are shown in the table(1).Figure(3)showes the maximum PGA of records of the components.The comparison of Mean squared normalized error performance function and correlation coefficient of the three designed Network has been shown in table (2) .Predicted PGA values for maximum PGA versus record number has been shown in Figure(4).

Table1. Result ofError and correlation coefficient for C-ANFIS Network.

error	Performance
0.075	MSE
0.513	NMSE
0.185	MAE
0.0018	Min Abs Error
0.601	Max Abs Error
0.821	R

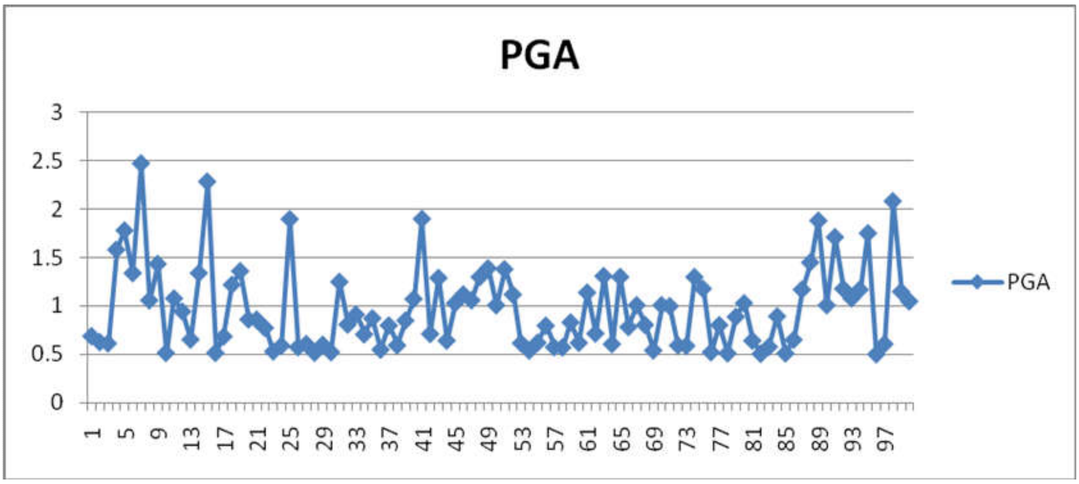

Figure 3 . Record values of maximum PGA used in this study.

Table2. Comparison of Mean squared error and correlation coefficient of the three Network. designed

DESIGNED NETWORK	*R*	*MSE*
ANFIS Network	0.28106	0.5131
SVR Network	0.9999	0.0001
RBF Network	0.2953	0.3160

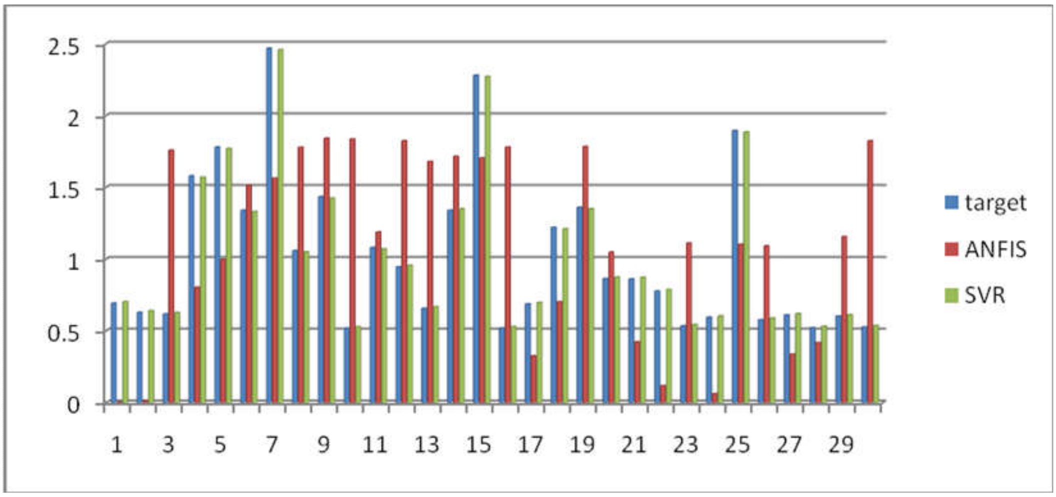

Figure 4. Predicted PGA versus record numbers for two Neural Networks (ANFIS and SVR).

CONCLUSION(S)

In this paper, to estimate peak ground acceleration in an area, three neural networks were applied and designed in order to predict the PGA in different earthquakes of the world. The comparison of the ANFIS and SVR models in Fig.4 shows that SVR designed network in this study could act better than ANFIS designed network in the PGA prediction. Therefore, the results show that SVM model can be used successfully in order to make accurate and reliable PGA forecasting.Finally, this conclusion shows that SVR and Co-Active Anfis Networks can be suitable and useful for predicting peak ground acceleration in future earthquakes.

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