Shear wave velocity prediction from petrophysical logs using MLP-PSO algorithm

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Introduction

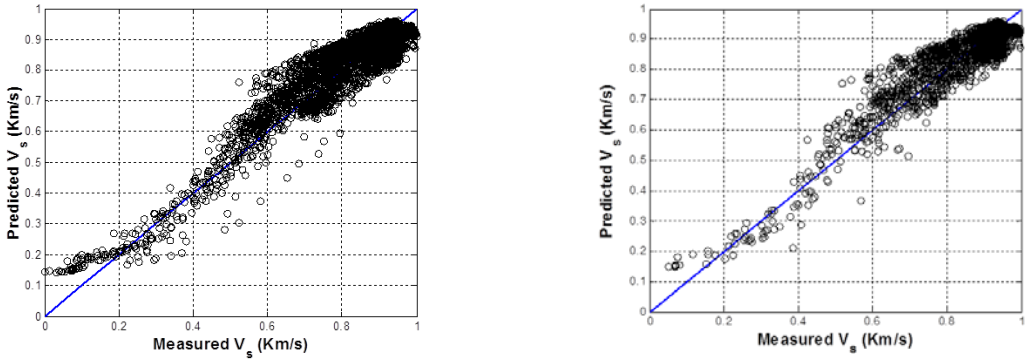
Dipole Shear sonic Imager (DSI) log is expensive, therefore, some companies prefer to use only DT. P-wave interval transit time log for common wells. In these cases, shear wave velocity can be estimated by empirical relations. A number of famous these equations have been published by Domenico (1984), Castagna et al. (1993), Broucher (2005) and Ameen et al. (2009). But note that all of these empirical equations are related to special oil field and well and they can not be able to predict a precise model for other fields and wells. Therefore, it is better that be used a specific correlation function to predict shear wave velocity for each field. Artificial intelligence methods are a computing system made up of a number of simple, highly interconnected processing elements, which process information by their dynamic state response to external inputs. These methods have been implied by many researchers in a wide range of sciences as a predictor successfully. In this study, the new successful artificial intelligence method has been used to predict shear wave velocity in a field case of Iran will be described herein.

Methods

Artificial intelligence presents more accurate results than statistical methods. Therefore, Multi-Layer Perceptron (MLP) neural network in combination with Particle Swarm Optimization (PSO) algorithm was employed as a tool to construct models of shear wave velocity predictor. In order to evaluate the shear wave velocity, a dataset was formed from petrophysical logs include of compressional wave velocity (V_P), rock density (RHOB), porosity (NPHI), Gamma ray (GR) and depth. There are 6560 data points in the studied range. Major issues considered to construct the neural network include data preparation, choosing input variable, choosing the type and structure of neural network, transfer function and training algorithm. Based on trial and error approach, [3 5 3] were obtained as the best MLP neural network structures for the dataset. Due to the fact that Leveneberg-Marquardt (LM) algorithm is one of the most effective training algorithm in speeding up the convergence rate of the MLP neural network, it has been widely used in practical estimation and classification problems. The LM suffers from the problem of trapping in local minima. To tackle this problem, PSO algorithm was used as a training algorithm for MLP neural network. Based on the results of sensitivity analysis, the number of iterations for PSO algorithm and population size were set to 200 and 50 respectively. Seventy five percent of data entered into the MLP neural network were chosen as training data and the rest 25% were chosen as test data. Input data of MLP neural network must be normalized, since large values of an input may dominate the effects of other inputs on the results of model.

Results and Discussion

As can be observed, the model converged less than 150 iterations. Figure 1 represents the comparison between predicted V_s and measured V_s values for the train and test data. As it can be seen, the MLP-PSO model exhibited a very good performance in predicting shear velocity in training and testing phases. Table 1 shows the mean square error (MSE) and R-square values for train and test data.



(a) *(b)*

Figure 1.Predicted shear velocity by MLP-PSO vs. observed shear velocity: (a) training and (b) testing data

Table 1. Final results of utilizing hybrid MLP-PSO algorithm

	MSE	R-square
Train data	0.0028	0.9458
Test data	0.0028	0.9360

Figure 2 presents a comparison between predicted results and measured data of shear velocity across the studied depth interval in the present study. As it can be seen, this model can serve as appropriate approach to shear velocity prediction at high accuracy at wells where no direct data on shear velocity available.

Conclusions

Results of constructed MLP-PSO models revealed that:

1- MLP-PSO method can be used to predict shear wave velocity by common petrophysical logs as input parameters.
2- Predicted shear wave velocities have enough accurate and they are reliable for making 1D and 3D geomechanical models.
3- This method can be used for predicting shear wave log for wells where located within main wells with DSI log.

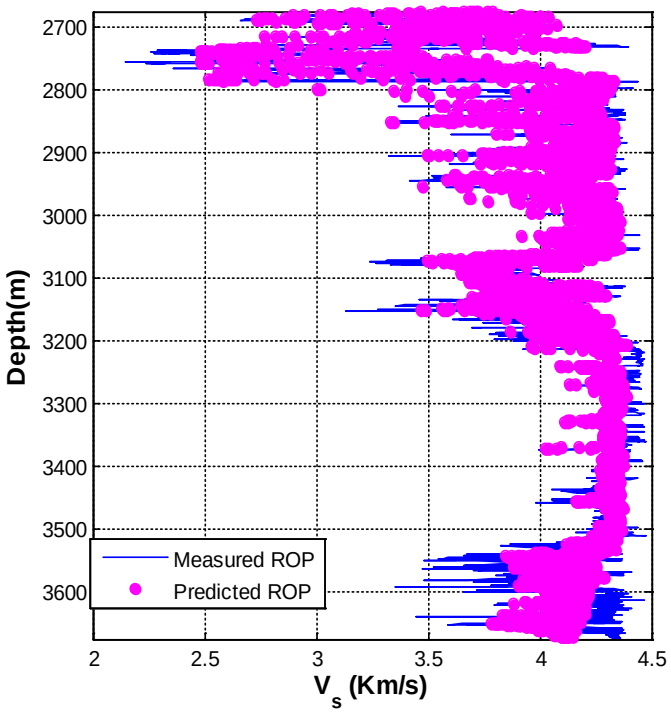


Figure 3. A comparison between real data and predicted results at the studied well using trained MLP-PSO model.

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