MACHINE LEARNING ALGORITHM FOR FORMATION PROPERTIES PREDICTION BASED ON WELL LOG DATA

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The evolution of the petroleum industry in theoretical and practical fields has led to an increase of the amount of used information. The correct analyze of such information volume is sufficiently difficult task. The inventions of new methods and new equipment stimulates the industry to use more automated digital methods of data analysis. This type of methods includes machine learning methods.

Neural network models predict the formation properties such as porosity and permeability in several research papers. In statement [4] neural network is used to determine water saturation and for porosity calculation. The fully connected back propagation network with one hidden layers is used to analyze data of four well logs: caliper log, sonic log, neutron and density logs. The correlation coefficient between real value of porosity and predicted is 0.82.

Another example of neural network implication for that task presented in statement [3]. The network with two hidden layers is meant to be used for porosity prediction. The input data contains: gamma ray, resistivity (lateral log deep), density log, neutron porosity log, photo-electric factor and acoustic log. The total error is 0.012.

The permeability calculation from well log data is performed in [4]. Such logs as gamma ray log, neutron log, density log are used. The object of study is Utah field in Uinta basin. The correctness of predicted data is confirmed by the correlation with measured core permeability with R^2 =0.977.

In scientific research [4] neural model is used for permeability prediction by well logging data analyze. Four types of logs are used: acoustic, density, neutron and resistivity log. The multilayered perceptron model with one hidden layer is used. The sufficient correlation between measured core value and predicted permeability is reached (R^2 =0.83).

In current article the object of interest is BV10 layer of Samotlorskoe field. Samotlorskoe field is a unique oil and gas field, also it is the largest oil field in Russia. For analyze 47 wells with core data are obtained. The raw data contain self-potential log, gamma ray log, induction log (induction log deep), resistivity lateral logging (four sondes with different depth of invasion).

In this research, the fully connected back propagation neural network is used. The net has three hidden layers. Input layer consist of 40 neurons in case of using sliding window method for forming an input signal. The window size is five depth point in which logging data was recorded. First hidden layer contain 20 neurons, next layer 12 and the last hidden layer has 10 neurons. In the end output layer consists of two neurons- one for porosity prediction and one for permeability. In all layers exclude the last hidden one Relu activation function is used. Sigmoidal activation function is used in output layer.

In raw data there are some problems: noises and abnormal high values (Fig.1), different logs variation in wells. The unbalanced input data was normalized by standard score calculation. The problem of various log representativity in wells was solved by forming a combined data set of 47 wells with core data that have the same array of logs.

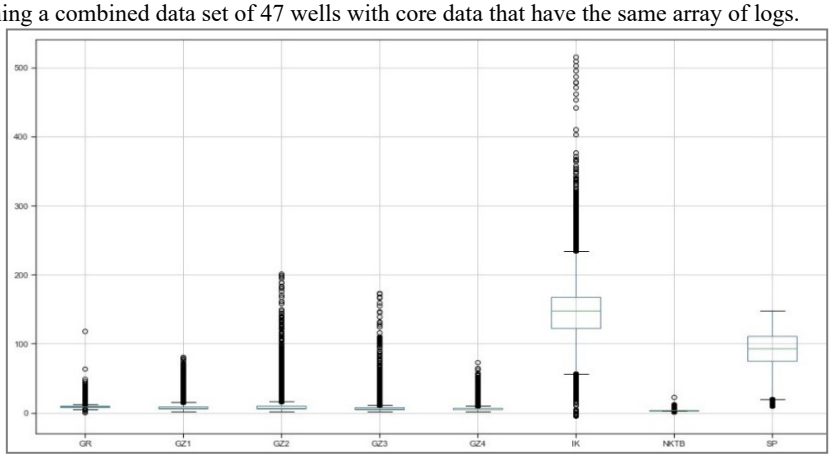

Fig.1 Box plot for used logs

To confirm that porosity and permeability do not have any strong dependence from any analyzed log data the correlation matrix was calculated (Fig. 2). Predictably data of neutron and self-potential logs shows the strongest connection with porosity value since these logs can be used to calculate the porosity. However, the correlation coefficient is less than 0,5 and the dependence is weak. The permeability value has non-linear relation with all analyzed log-data, because there is no log that can measure the permeability.

The input data was split in proportion 70% for learning and 30% for testing. For visualization of predicted results, all data from well 2Z was added for testing. The final results of porosity and permeability prediction for well 2Z is shown in figure 3. In general, the mean absolute error for porosity determination is 0,02 and 2,2 md for permeability value.

The predicted porosity and permeability values in well 2Z shows sufficient correspondence with measured core values. Unfortunately, core properties are mostly measured in pay zones and there is a little information about shale and tightsand porosity and permeability. Despite the fact that the neural network does not have enough examples of shale and tightsand properties for learning process it correctly predicts low values for that zones.

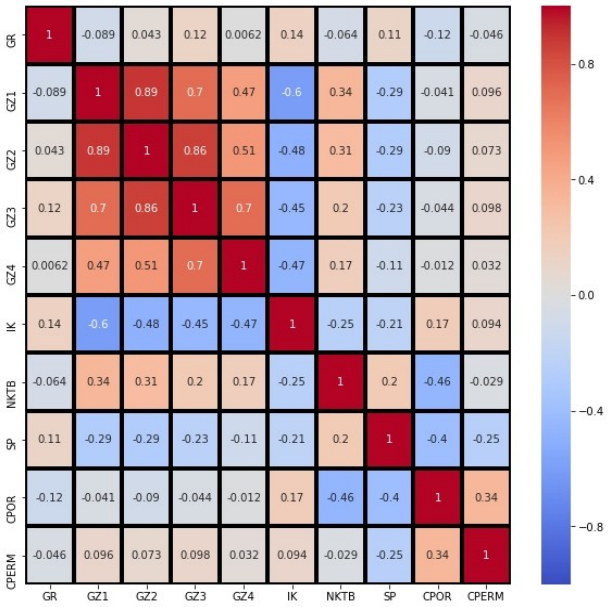

Fig.2 Correlation matrix for analyzed data

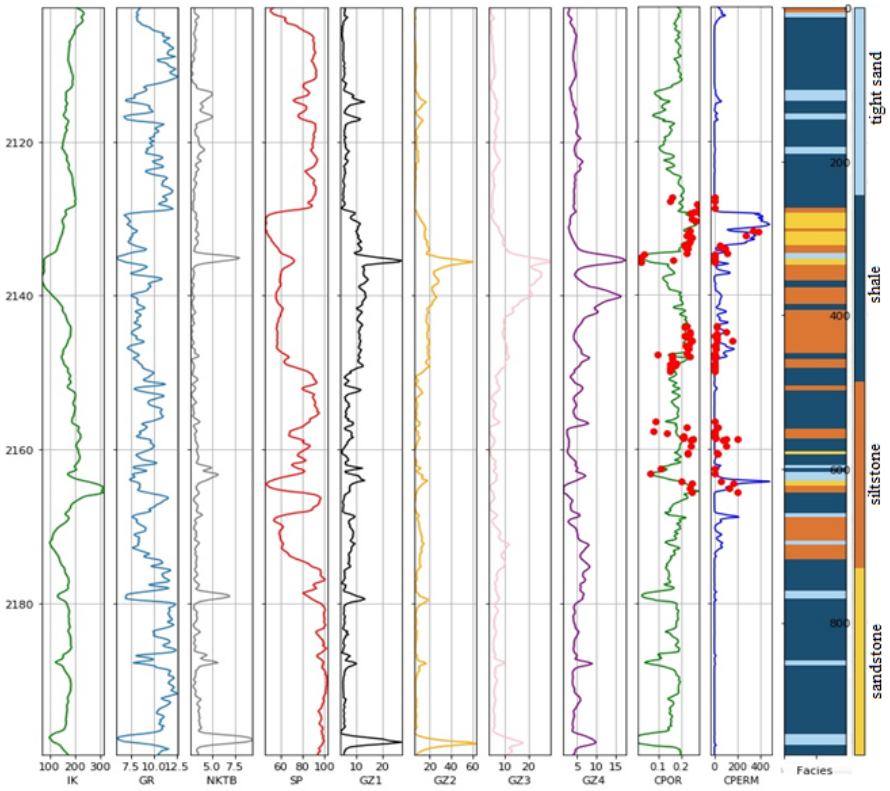

Fig.3Prediction of porosity and permeability for well 2Z

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