Chapter 6
Water Content Prediction in Geophysical Exploration Based on BP Network

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Abstract This research is adopting neural network technology for the use of a number of known geophysical testing the well Pumping test data to the geophysical parameters of aquifer discharge umts with single-hole model composed of the training sample set, establishing the err BP network forecasting model for regional geophysical methods unknown under ground water content prediction, this will be major improvement to the traditional water content prediction.

Keywords Artificial · Networks · Integrated · Geophysical methods · Water content prediction

6.1 Introduction

Water resources is a human production and life indispensable natural resources, biological survival of the environmental resources, with the water crisis intensifies water quality deterioration, water shortages have evolved into the world paid close attention to the resources and environmental problems one. Groundwater is an important part of water resources, human indispensable natural resources, its life, industrial and agricultural production, and urban construction, social and economic development plays a significant role.

In the North China Plain region, due to the large-scale development of groundwater use in the past 40 years, has been formed around Shijiazhuang, Hengshui, Changzhou, and other cities of the three regional funnel. With the

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continued exploitation of groundwater resources, the composition of the groundwater resources component has changed significantly. According to different model results, the more flow in the deep water resources and clay layer released water accounts for about 75 %, about 15 % of the released water sand laminated, lateral recharge in only 10 %. Noncompensation means that the status quo adopted most of the water from the aquifer storage resources, and has caused serious land subsidence, which also allows us to re-examine the use of groundwater resources.

Based on geophysical methods to groundwater in situ testing capabilities, with high efficiency, low cost, continuous measurement of other advantages, the use of geophysical techniques to predict the water content of the aquifer is expected to solve the above problem has become the hot topic of current research. Therefore, geological modeling technologies and integrated geophysical study the combination of aquifer water content forecasting methods that have emerged. Ground of integrated geophysical techniques, three-dimensional distribution of the fine to identify aquifer and changes; to carry out ground geophysical technology research, precise computation of aquifer effective porosity, permeability, effective saturation, shale content, and other geological parameters; Finally, geophysical parameter mathematical model, to carry out the moisture content of the aquifer, the prediction processing system.

6.2 The Basic Theory of Artificial Neural Networks

The artificial neural network is an emerging cross-disciplinary. In the practical application of artificial neural networks, artificial neural network model uses BP neural network (back-propagation neural network) [1]. The BP algorithm consists of two parts: the forward pass and error back-propagation of information. In the process of the forward pass input information calculated from the input layer hidden layer, layer by layer to the output layer, each layer of neurons status affects only the state of the next layer of neurons. If the output layer does not have the desired output, the calculation of the change of error value of the output layer, and then turned to the back-propagation, the error signal through the network along the connection path to anti-pass back to modify the weight of the layers of neurons until they reach the desired goals, Fig. 6.1. BP neural network learning rules: adjust the network weights and thresholds of the square of the network errors and the smallest; it is to adjust the network weights and thresholds in the direction of steepest descent [2].

BP model consists of multiple nodes of input layer, hidden layer, and an output of the output layer, each node of individual neurons, and one-way connection between adjacent layers. Transfer function between the nodes for the S-shaped function, i.e.,

$$f(x) = \frac{1}{1 + e^{-x/Q}} \tag{6.1}$$

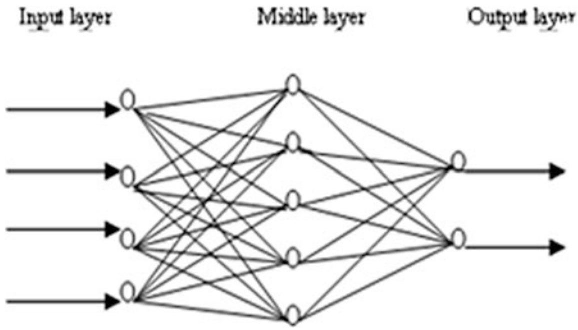

Fig. 6.1 BP ANN module

The output of the layers of nodes is calculated as follows:

$$y = f\left(\sum_{i=0}^{n} w_{ij}\, x_i - \theta\right) \tag{6.2}$$

Each node input is connected by the weights ω of the input information and the threshold θ. Where y is the node output, xi is the node to accept the information, ωij is related to the connection weights, θ is the threshold, and n is the number of nodes.

6.3 Geophysical Method

Geophysical methods are divided into the power law and elastic wave method. Which is the power law: (1) transient electromagnetic method (TEM), (2) conductivity imaging method (AMT), (3) induced polarization (IP), each method has its advantages and characteristics, such as [3, 4]: exploration of the direct current method to detect saline very invasively, and water distribution; seismic exploration method in the constructor, stratigraphic division, strata rich water, and lithology contrast with a strong ability; electromagnetic sounding method has the absolute advantage of the exploration depth. Therefore, the response to different exploration tasks, a variety of geophysical methods optimized combination of comprehensive analysis, a key aspect of this research project, several geophysical methods have been used to extract the different combinations of the following prediction model:

In areas of shallow aquifer level for example, the Quaternary aquifer structure of the North China Plain region alone IP method, which have come to the use of its measurement and inversion of resistivity, polarizability, half-life, and decay rate layer thickness parameters is sufficient to model prediction;

For Aquifer of the fine-grained structure and the stratigraphic sequence, litho logy characteristics can be taken to stimulate the pattern of the polarization and shallow high-resolution seismic method or the TEM in addition to the forecast model can also aquifer structure of a more nuanced understanding of;

For the deeper aquifer structure of the Ministry, we recommend the use of frequency domain electromagnetic sounding method, the exploration depth of the electromagnetic method, conditional case with seismic exploration, can be the physical parameters of the deeper geological, which improve the prediction accuracy to a great help.

6.4 BP Neural Network Model

6.4.1 Modeling Selection of Neurons

Predecessors have been confirmed by a large number of field and laboratory test, the subject of forecasting model selection of input neurons to the following principles: First, the existing geophysical equipment can be measured, or the conversion parameters, practical and observability; second, to be matched with the comprehensive geophysical methods to study the fine structure of the aquifer to fully tap the received observation data resources; optimal combination, taking into account the complementarities between the input neurons use to avoid or reduce redundancy; Fourth, for the protection of the prediction model has a broad generalization ability.

Based on the above principles and before the text of the discussion of integrated geophysical methods which provide the geophysical parameters the amount of the initial neural network prediction model's prediction input basic neural element selected is: ρ, h, st/2, D, ηs such as ground geophysical observation parameters (resistivity ρ, h, aquifer thickness, St./2 half-life D attenuation ηs polarization rate).

6.4.2 Normalized Input Neurons

Because each unit of data collected as the input neurons are inconsistent, the scale difference of the input neurons, there will be a large sample to eat small sample, and therefore must be the input layer data (0, 1) normalized to eliminate the impact of the scale. Commonly used normalization formula is:

$$x_s = \frac{x - x_{\min}}{x_{\max} - x_{\min}} \tag{6.3}$$

where: x is the corresponding value of an input parameter; $X_{\min}$ and $X_{\max}$ are the neurons set minimum and maximum values; X_s, a normalized value of the input parameters. The output form of an output and little change in magnitude, there is no need to take the normalized output neurons.

6.4.3 BP Training

Has been collected from the sample divided into three separate parts, namely the training set, validation set, and test set. The training set used to estimate the model, the validation set is used to determine the parameters of the network structure or to control the model complexity, while the test set to test the final choice of the optimal model performance. A typical split is 50 % of the totals sample of the training set, while the other 25 % each; three parts are randomly selected from the sample.

Shijiazhuang City Xima Zhuang and Beijing Chaobai two water source data model of the work rely on currently at our disposal, respectively the Xima Zhuang, and the Chaobai two water to take out a well data as a predictor of promotion sample set, the two 13 wells in the area as a training sample set have been previously described to normalize after a treatment sample data is shown in Table 6.1.

6.4.4 Result

The modeling has taken a global optimization algorithm Levenberg–Marquard method training function with trainlm functions, the results shown in Table 6.2.

BP neural network prediction model pointed out the applicable conditions in this way; by testing the trained model, we have come this way the model error is less than 5 %, to achieve the purpose of modeling.

Table 6.1 Sample data of ANN model

NO		Q	T	S	D	η
Training set	1	25	0.23	0.15	0.35	0.4
	3	34	0.32	0.1	0.42	0.47
	6	70	0.71	0.5	0.84	0.6
	7	27	0.11	0.1	0.6	0.33
	8	35	0.32	0.25	0.64	0.47
	11	38	0.36	0.27	0.67	0.47
	35	50	2.76	0.14	0.5	1.07
	37	51	2.39	0.11	0.44	1.2
	20	40.82	2.97	0.22	0.48	1.01
	33	64.28	1.91	0.14	0.57	1.33
Validation set	4	45	0.34	0.3	0.77	0.53
	1–2	48.93	2.67	0.14	0.39	1.08
Test set	1–34	51	2.39	0.1	0.48	1.07

Table 6.2 The experimental results

NO	1	3	6	7	11	35	37	20	33	4	1–2
Q	25	34	70	27	38	50	51	40.8	64.2	45	48.9
Forecast	25.5	33.7	71.0	26.3	37.8	49.2	50.5	40.2	63.9	44.3	48.8
Error (%)	2	0.9	1.5	1.4	0.5	1.6	1	1.4	0.5	1.6	2.2

6.5 Matlab Program for Main Framework

Described in the previous paper, the network structure, training samples, and the learning algorithm to determine, set the training parameters of the network of which the largest number of training is 1,000, the expected error Inse le 6, the momentum factor of 0.9, the initial learning rate of 0.01, incremented by a factor of 1.05, decreasing multiplication factor of 0.7, the maximum error rate of change of 1.04. Before training, you first need to set the initial value of weights and thresholds the function newff () that generate the BP network weights and thresholds of the network layers is done automatically initialized.

Initialization command: net = init (net);
Initialized weights, the initial value of the threshold 0.
Training process, one of the following conditions, the training will end:
exceed the maximum wonderful 11 practice, namely. The ehs namely ep. of ChS > 1,000;
The command statement: net. Trainparam Epochs = 1,000:
performance function value is less than the error indicator g. a1 the mse core 10 a;
Command statement: net. Train Aram. Goal = 0.000001:
training longer than a time limit time.

The subject application matlab7.0 aquifer water content of the BP neural network prediction model for training, training results are shown in Fig 6.2.

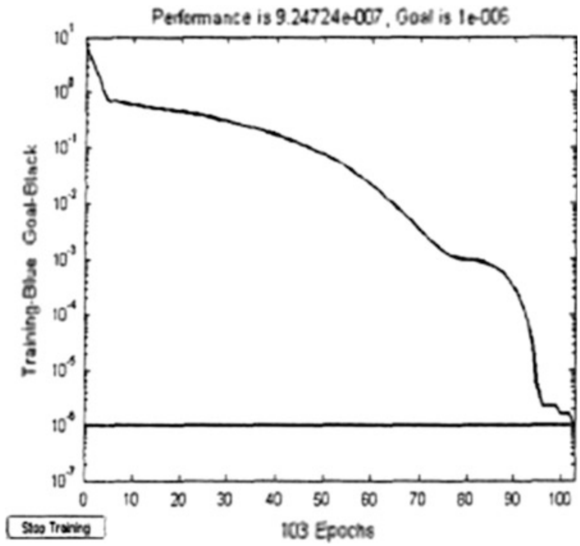

Fig. 6.2 BP neural net work forecast model training results error convergence curve

6.6 Conclusion

In this paper research results show that the BP neural network model combined with the integrated geophysical techniques during aquifer water content forecasting has certain advantages and potential. But at the same time we also have to point out, this subject is still price segment, objective reason for the data collection stage a summary of research, there is still some. By the initial results of the project is summarized, and found there are still the following issues need further study and improve the future work.

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