Optimization of the Connection Weights and Thresholds in the Seismic Inversion Neural Network Algorithm

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Abstract
In the seismic inversion model, as the neural network algorithm there are some problems, the convergence bad, accuracy is not high. This paper presents a seismic inversion based on artificial fish Swarm Optimization neural network models. First to initialize fish mapping of chaos optimization and ergodicity of artificial fish-swarm search and adaptive strategies of artificial fish-swarm algorithm of optimization search strategy, and using as a parameter change measure, in the course of operation of the algorithm Adaptive adjustment of parameters, and finally building seismic inversion based on artificial fish Swarm Optimization neural network model. Simulation experiments show that improved artificial fish-swarm algorithm presented in this paper has better accuracy optimization, artificial fish-swarm algorithm of neural network based on improved convergence properties better and seismic inversion algorithm based on improved neural network model of mean-variance changes more slowly.
Key words: SEISMIC INVERSION, NEURAL NETWORK ALGORITHM, ARTIFICIAL FISH ALGORITHM, CHAOTIC MAP, ADAPTIVE STRATEGY

1. Introduction

Seismic inversion technology is a new method along adhibiton of the seismic technology in oilfield exploration. However, there are some the uncertainty in seismic inversion technology, such as multiple solutions, the complexity of the reservoir, the limitations of application conditionsand the quality and lower resolution of the data of conventional post-stack seismic.All above make this method having limitations inapplication in a very great degree, so the study of this method will be different according to different [1]. At present, the application of seismic technology has been used not only in the morphology of the tectonic research but also in the reservoir evaluation, not only in the early stages of exploration but also in the stage of development. Accompanied byfurther applicationin seismic technology in oilfield exploration and development, seismic inversion

technology is also developed and become an emerging discipline [2].

Geophysical inversion was put forward by the scientists who have curiosity about the earth's interior structure, and has a further study in the efforts of the development of physics and geology. Easley and Shivemake a further study in the application of stochastic simulation in geophysical subject, and gradually the condition and the unconditioned stochastic simulation were formed, which is used in reservoir description. A large number of modelsshould beprioritized and selected in the condition that only some of the simulation production of lithological parameters results will be used [3]. There are many ways to sort the results. In order to provide some model which has upper and lower limit and expectation in oil calculation and reservoir management, and only make fine simulation according to a few results in the sequence, Deutsch and Srinivasanput forward some different sorting technologies. The study of the sorting method has become an important direction in the research of the impact of uncertainty to the quantitative reservoir[4]. Zhu-sheng zhou first put forward the method which can overcome the shortcomings of a single linear inversion. Comprehensive constrained inversion which uses the geological, seismic and logging data was used in this method [5]. In order to solve the problem that there the noise cannot be eliminated in the the single channel of the inversion method, Li Hanging puts forward theory which combines the recursive inversion with broadband constraint inversion [6]. On the basis of these theories, Wang zhizhang, Wang jiaying and Qian Rongjun put forward the sparse pulse inversion method, broadband constraint inversion and logging data inversion and lithologic constrained inversion and other supporting technology [7]. As more and more significative thoughts has been put forward in the inversion of earth , nonlinear intelligent optimization technology research including artificial neural network ANN [8], genetic algorithm GA [9] and so on have been the center work of geophysical experts and scholars. One hand, they try to improve this method, on the other hand some effective solution has been put forward. The new theory has brought the exception in the seismic inversion [10], oil and gas reservoir prediction, which are in poor condition.

In order to solve the problem of neural network algorithm in seismic inversion in the model, this paper proposes an optimization based on artificial fish seismic inversion model of neural network, and the simulation experiment has proved that the model is useful.

2. The analysis of the defects in neural network algorithm

The BP neural network is a kind of multilayer feed forward network, the transfer function of neurons in the model is S function, the output which is continuous is between 0 and 1, it can reflect arbitrary nonlinear mapping from input to output. The picture below is the basic structure of BP neural network model.

BP Neural Network algorithms and said as follows：

$$S_{pj} = \sum_{i=1}^{n} w_{ij} \cdot x_{pj} - \theta_j \quad (1)$$

$$b_{pj} = f(S_{pj}) \quad (2)$$

$$t_{pk} = \sum_{i=1}^{L} w_{jk} \cdot b_{pj} - \gamma_k \quad (3)$$

$$C_{pk} = g(t_{pk}) \quad (4)$$

Forward calculation and error reverse adjustment is thelearning process of the neural network, Sigmoid function which was take the logarithmic was regarded as the excitation function. The error back propagation process is as follows:

(1) Assign random numbers to the connection weights and thresholds.

(2) Operate as the type (1 ~ 4).

(3) The calculation of the number K neuron error of δ_{pk} which is from the P output layer is shown in the following type

$$\delta_{pk} = C_{pk}(1 - C_{pk})(y_{pk} - C_{pk}) \quad (5)$$

(4) The calculation of the number J neuron error of δ_{pk} which is from the P output layer is shown in the following type

$$\delta_{pj} = b_{pj}(1 - b_{pj})\sum_{j=1}^{L} w_{jk}\delta_{pk} \quad (6)$$

(5) Calculate the adjustment amount of the connection weights and threshold between the output layer and interlayer.

$$\Delta w_{jk} = \beta b_{pj}\delta_{pk} \quad (7)$$

$$\Delta\gamma_k = \beta\delta_{pk} \quad (8)$$

(6) Calculate the adjustment amount of the connection weights and threshold between the input layer and interlayer.

$$\Delta w_{ij} = \beta b_{pt}\delta_{pj} \quad (9)$$

$$\Delta\theta_j = \alpha\delta_{pj} \quad (10)$$

(7) Get a new connection weights and thresholds.

(8) Repeat the operation after taking the connection weights and thresholds got in type (7) into type (2).

(9) Judge whether the output meets the requirements $|y_{pk} - C_{pk}| < \varepsilon$ (ε is precision value), retreat the algorithm if the result fits.

Neural network itself also has the certain problems. So something must be done to solve the problem that it`s easy to become local optimum when large data is dealt with.

3. Weights and threshold optimization based on neural network model

3.1. Improvement of artificial fish-swarm algorithm

Artificial fish-swarm algorithm is an artificial intelligence algorithm based on nature fish feeding behavior. In this paper, we optimize the BP neural network algorithm with artificial fish-swarm algorithm and improve the original algorithm.

First, initialize the fish for the optimization of chaotic mapping:

Logistic mapping is a class of chaotic system which is very simple but has been widely used. Its definition is as follows:

$$Z_{k+1} = \mu Z_k (1 - Z_k), Z_k \in (0,1) \quad (11)$$

In the sequence of real numbers, the control parameters for the system.

This article will search in the process of introducing the idea to initialize a shoal, ergodicity is chaotic motion characteristics of chaotic motion in a certain range according to its own "laws" do not repeat to loop through all the State, accessible after the end of the chaotic motion of the optimal value, which can be used to improve the basic fish-swarm algorithm in convergence speed of fish scale. The basic idea is to bring chaos to the optimization using chaotic maps variable and traverse range enlarged to chaotic motion of a variable range of values, and then search using chaos optimization. To solve the complex function's maximum value, for example, mathematical model for optimization problems are:

To solve the complex function's maximum value, for example, mathematical model for optimization problems are:

$$\max f(x) = f(x_1, x_2, ..., x_n), x_i \in [a_i, b_i], i = 1,2,...,n \quad (12)$$

In a chaotic artificial fish-swarm algorithm initialization steps are:

(1)Known chaotic variable number of iterations, you can get the initial chaotic sequences, sequences of which range of values, but skipped the Logistic mapping fixed point.

(2)In accordance with the draw and calculate. While the iteration count.

(3)According to the Logistic map chaotic variables are obtained by iterative sequences. According to fitness function variables, and functions based on a formula.

(4)When, and if, so,. At that time, and remains the same, orders, go to step (2), when it reaches a preset maximum number of cycles when searching stops.

(5)When the search is complete, get a new chaotic sequence, this sequence is through the initial chaos of the initial state of the artificial fish-new, artificial fish at this time the location is closer to the optimal area.

With chaotic thoughts to initialize a shoal of fish, that is, when there is no change of artificial fish-swarm algorithm to initialize the randomness of nature, and increases the ergodicity of artificial fish search, improving the basic fish-swarm algorithm in convergence speed of fish scale. After the initial chaos of the fish to make artificial fish Swarm Optimization within the preliminary optimization, improved convergence properties of the basic algorithm.

Then, the adaptive strategies of artificial fish-swarm algorithm of optimization search strategy. First of all, to define optimal Adaptive value variance of rate of change and change:

$$k = \frac{f(t) - f(t-n)}{f(t-n)} \quad (13)$$

$$\sigma = D(f(t), f(t-n), f(t-2n)) \quad (14)$$

For stocks in the best fitness value, for the population in the best fitness value, less for stocks in the best fitness value, indicates that optimal adaptation in the relative rate of change, said changes in the variance.

Use game theory as a measured parameter change, the algorithm in Adaptive adjustment of parameters during the operation, implementation is as follows:

$$\begin{cases} step = f(step), \delta = f(\delta) & K \le \theta, \sigma \le \phi \\ step = step, \delta = \delta & K > \theta, \sigma > \phi \end{cases} \quad (15)$$

Among them, the step size adjustment according to the algorithm performance accordingly, generally after a first-principles of small, because according to the segmentation optimization theory, early steps to find the best value field, later reducing the step size can improve search accuracy, prevent local convergence; Said the congestion factor be adjusted accordingly; For evaluating coefficient and adjusted accordingly in accordance with different problems.

3.2. Neural network model based on artificial fish-swarm algorithm

Steps to improve the artificial fish-swarm algorithm of neural network are as follows:

(1)Determining the structure of BP neural network: the network is divided into three layers, one input node and hidden layer node, output layer has a point.

(2)Determine the dimensions of the artificial fish: artificial fish dimension includes the weights of BP network and thresholds, namely:

$$X = X(v, \mu, w, \theta) \quad (16)$$

(3)Initialize the algorithm parameters, including: population size; and distance of the artificial fish artificial fish the maximum step size; congestion factor; maximum number of iterations and precision chaos factor; factor; optimal continuous the same number of times.

(4)Setting the initial number of iterations, personal individual fish in the feasible region, forming the initial fish, and that each component be (− 1, 1) random numbers within the interval.

(5)Calculate the initial current location of artificial fish individual fish food concentration value, and compare sizes, retain the value into the Bulletin Board.

(6)Artificial fish respectively improved the following behavior and improved cluster behavior, choose a larger value after the practical implementation of action, the default behavior for improved foraging behavior.

(7)Updated every iteration a bulletin board, if there is artificial fish is better than a bulletin board, then replaced; otherwise, if the value of continuous iteration times Bulletin Board had not changed, simulation of escape behavior.

(8)Abort conditions: judge whether it has reached the maximum number of iterations or solution accuracy is reached, if it satisfies one of the conditions on the value of the output Board, otherwise, go the step (6).

When the escape occurred when assuming a chaos factor of, each fish in the fish generate random numbers, if you put the fish in the chaos pool. Then put the fish in the chaos pool 22 pairs, hypothesis and chaos pool is two fish, two fish are in hidden nodes of, that is, when the initialization time of chaos, exchanging the corresponding location on the hidden node, as well as connections to the hidden node, so better save the local structure of the individual. Hypothesis and chaos during initialization, to Exchange is the first hidden node, as shown in the following figure:

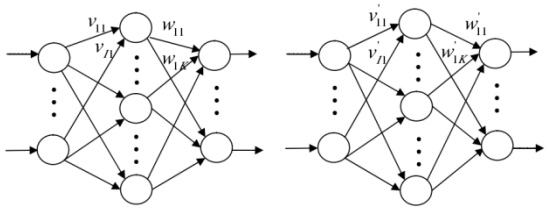

Figure 1. Point initialization before the first hidden knot

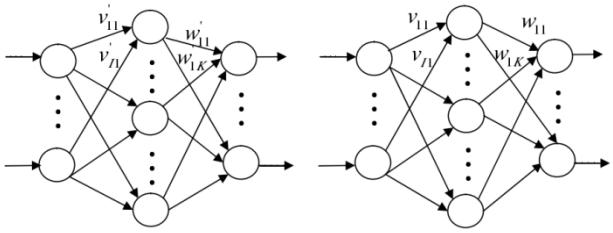

Figure 2. After the first hidden node initialization

3.3. Seismic inversion based on improved neural network model

Seismic inversion based on improved neural network model of key steps are as follows:

(1) Number of nodes to determine the input and output layers. According to the results of the preceding data processing, neural network input node number is set to 5 (wave impedance, clay content, band-pass filter, permeability, porosity). Because the network is log value of the output, the output nodes are designed to 1. Hidden layer neuron transfer function is a Sigmoid transfer function:

$$f(x) = \frac{1}{1+e^{-x}} \quad (17)$$

(2) Determine the number of hidden layer nodes. Our selection of neural network models are 5 inputs and one output, on the number of hidden layer node selected, taking full account of the approximation accuracy at the same time, try to make the generalization ability. To do this, we use experience and experimental method of determination is made, if the input and output nodes and, the ideal number of hidden layer nodes in the following range selected.

$$a = \frac{M+N}{2} \le L \le (M+N)+10 = b \quad (18)$$

Where to search, take 6, and see network performance and then take 10 and 16, respectively, and compared with the forecast performance, testing intermediate layer neurons number effect on network performance. When the network minimize the prediction error, and network middle layer of neurons is the best value.

(3) Learning rate is reflected in a circuit training weight variation, the convergence of speed and accuracy of prediction has a significant impact, in order to take into account forecasting accuracy and convergence, the learning rate is set to 0.09.

(4) Hidden layer of BP neural network in this article done using Sigmoid transfer function, infinity, a range of input variables, compressed to a limited range of values of output variables. Value when the input variables is large, and its

slope tends to zero. Linear output layer Purelin transfer function.

(5) Selection of initial weight and threshold value for network convergence, whether it reached a local minimum and convergence rate has a significant impact. Under normal circumstances, we hope that the initial value-weighted each neuron's output value is close to zero, so you can ensure that each neuron weights are able to regulate their activation function changes the maximum. We here initial weights and threshold values for (-0.5,0.5) random numbers.

4. Algorithm performance simulation

In order to verify the improved algorithm performance, first artificial fish-swarm algorithm for improved performance using multimodal function to be the best and worst values are calculated, the result is as follows.

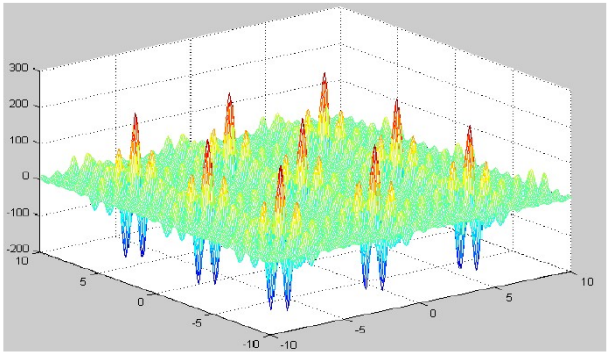

Figure 3. Multimodal function curve

Table 1. Improved comparison results of AFSA

Item	Numerical
Best value	-187.8
Original algorithm optimal value	-181.3
Original algorithm worst value	-138.8
Improved algorithm optimal value	-187.5
Improved algorithm worst value	-188.2

Then based on artificial fish-swarm algorithm of neural network model for the convergence of the simulation, the result is as follows:

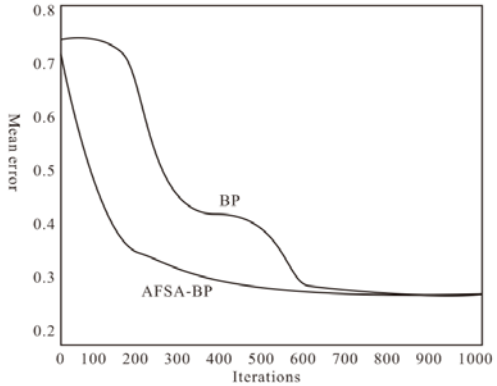

Figure 4. Improved convergence of neural network model simulation

Finally, the B2-1-439 data, for example, seismic inversion algorithm based on improved neural network model for simulation and comparison with standard algorithms, the mean square error curve shown in the following figure.

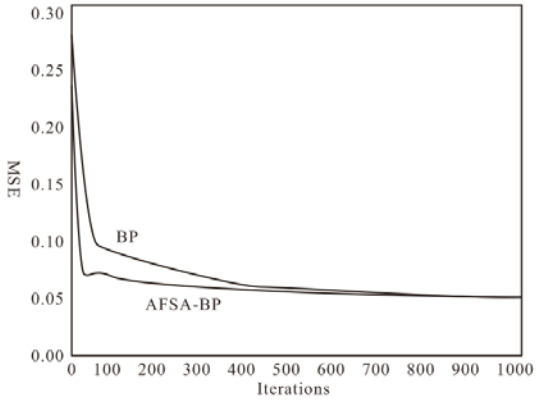

Figure 5. MSE seismic inversion curve

Can be seen from the above results, this paper puts forward the improved artificial fish algorithm has better optimization accuracy, convergence of neural network based on improved artificial fish algorithm is better, and the seismic inversion model based on improved neural network algorithm of mean square error change more slowly, so this paper puts forward improvement strategy of practical and effective.

5. Conclusions

With an ever increasing demand, exploration continues to deepen and the increasing scarcity of structural traps, purposefully looking for subtle oil and gas reservoir becomes more and more important. Recently years development and input application of storage layer earthquake anti-played, in description storage layer aspects, can better to will measuring well and the drilling information longitudinal resolution high, but horizontal sparse of features, and earthquake information longitudinal rough, but horizontal intensive of features organic combined, to more accurate to description storage layer of thickness and geometry form, then estimates storage layer of real sex changes, sharply improve drilling success rate. According to the seismic and well data inherent characteristics and present situation of the application of inversion techniques to develop, through inversion data processing practices, our study summarized in application of seismic inversion technology in reservoir key issues and propose solutions, and expectations play an important role in the exploration and development of oil and gas fields. This paper presents an algorithm based on improved neural

network model of seismic inversion and simulation results show that the model has a better effect.

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