Study on Classification for Remote Sensing Image based on BP Neural Network

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Abstract: In order to eliminate the ambiguity and uncertainty exist in the conventional classification for remote sensing images, the BP neural network was presented. However, the BP network itself also exist some limitations and shortages which are primarily represented in the aspects of network training speed low, optimization for convergence to integer not easy and so on. This paper improves the BP neural network based on MatLab software by using momentum and Adaptive learning rate. After 300 times of training for a sheet of panchromatic remote sensing image, the characteristics of original image can be emulation ally output reality. The total accuracy for classification is 86.57%, Kappa coefficient is 0.82, so that the precision can meet the needs of the classification of remote sensing images.

Key words: BP neural network; remote sensing; classification;

I. INTRODUCTION

In resent years, neural network has been widely used in the classification of remote sensing images. Many scholars have brought forward different methods in the monitoring classification of remote sensing images such as BP network, Hopfield network, ART, self-organized feature mapping model and so on, in which the classification precision is improved in a high degree. However, the classification precision depend on the sample selection in network training, and meanwhile, some methods, say BP network, exist lot of shortcomings such as low speed in network training, being not totally convergent, falling in local minimum value and so on. The improved feed forward network (BP neural network) model is applied in the study to cart through the classification and processing of remote sensing images, in which the training speed is increased and it can avoid to fall in the local minimum value so that it can reaches the goal of improving the precision in classification.

II. SUMMARY OF BP NEURAL NETWORK AND ITS IMPROVED ALGORITHM

BP model is one of ANN model, which is studied and applied widely. It is neural model put forward by PDP group consisted of Rinehart and other scholars in 1985 and its configuration is shown in Figure 1. It is proved theoretically that a BP neural network model of three layers can realize arbitrary sequent mapping.

BP neural network applies the error reverse transforming learning algorithm and grads searching technique to realize the mean variance minimization of actual putout and expected putout in the network. The learning process is consists of forward propagation and backward propagation via this kind of network. In the forward process, input signals from the input layer are processed by hidden units layer by layer and then sent to output layer, in which the state of each layer of neurons only affects the neurons state of its lower layer. If the expected output in the output layer can not be obtained, the process go to backward propagation, and the output error is to be backtrack through the primary link access. Modification for the neurons weighted values of every layer can make the error signal minimized. After the suitable linking value of network is obtained, the nonlinear mapping can be carried through to the new samples.

A. Limitation and shortage of BP algorithm

Although the backward propagation has gotten a wide apply, there are still some reverse limitation and shortage existed as below:

1) A long training time consumed;

2) Some phenomenon of lull-networks may be happen to nearly halt the adjusting process of network weights and cant complete training;

3) It is easy to fall in the local minimum value so not convergence to the total optimization.

B. Improving of backward propagation algorithm

In the past several tens of years, many scholars have studied thoroughly on the problem of backward propagation
and brought forward a lot of improving suggestions. The main goal is to speed up the training, avoid falling into the local minimum value and improve its capability. The improving methods of the first two cases of capability are studied in the classification application of remote sensing images in the paper.

1) Additional momentum method

When network modifies the weights using additional momentum method, not only the function of error in the grads, but also the affect of changing trend on the error curved surface is considered. The function is just like a low-pass filter, and allows the network neglect some tiny changing characteristics. Without any additional momentum, the network may fall into a fleet local minimum value, but with the additional momentum it might skim over the minimum values.

The judge condition in the programming training by using of momentum method is:

\[
mc = \begin{cases} 
0 & SSE(k) > SSE(k-1) \times 1.04 \\
0.95 & SSE(k) < SSE(k-1) \\
\text{mc others} & \text{others}
\end{cases}
\]

2) Self adapting and adjusting of learning speed

To a specified problem, it is not easy to select a suitable learning speed, so is based on the experience or experiment usually. However, the learning speed resulting in satisfied efficacy at the initial stage may not suitable to the later training. In order to resolve this problem, it used to apply the learning speed of self-regulation. The below equation shows a speed of self-regulation:

\[
\eta(k+1) = \begin{cases} 
1.05\eta(k) & E(k+1) < E(k) \\
0.7\eta(k) & E(k+1) > 1.04E(k) \\
\eta(k) & \text{others}
\end{cases}
\]

Where the selecting scope of initial learning speed is arbitrary in a great degree.

3) Momentum and self-regulation algorithm in learning speed

When the above momentum method is used, the total optimizing value can be extracted by using BP method, so that both of methods can be applied to train the neural network and known as momentum and self-regulation algorithm in learning speed.

III. EMULATIONAL EXPERIMENT OF BP NEURAL NETWORK BASED ON MATLAB IN CLASSIFICATION OF REMOTE SENSING IMAGES

A. Data preprocessing

Some preprocessing should be finished to a scene panchromatic remote sensing image such as radiometric correction, spectrum enhancing, eliminating of random noise and so on.

B. Constructing of BP neural network based on Matlab

According to the basic model and the BP algorithm of BP neural network, the BP neural network of tree-layers consisting of single hidden layers is to be established. there are 3*71 neurons in the node of input neurons’ layer, 25 neurons in the hidden layer and the output layer is a three-dimensional matrix of [1 0 0], [0 1 0] and [0 0 1]. The training sampling is carried through the preprocessed images according to the classification, and the Eigen values and their mean value are computed using Matlab software.

C. Training for BP neural network

1) The network initializing uses a group of small random numbers to the weight W and the deviation B of each layer and some parameters of weight modifying are also set up such as learning speed lr, minimum expected error err_goal, maximum cycling number max_epoch, initializing momentum factor, etc. The procedure is executed by the below Matlab software.

   S1=25;          %number of hiddennodes
   [W1, B1]=rands (S1, R);  %weight and deviationinitializing
   [W2, B2]=rands (S2, S1);    %maximum traningtimes
   max_epochs=300;     %maximum traningtimes
   lr=0.01;            %initial learning speed
   err_goal=0.001;     %goal error
   err_ratio=1.04;     %error ratio
   momentum=0.95;     %increasing multiple factor
   lr_inc=1.05;        %decreasing multiplefactor
   lr_idec=0.7;        %initializing momentumfactor
   Mc=0; dW1=0; dW2=0; % Mc=0; dW1=0; dW2=0; % initializing momentumfactor

2) The output vectors A1 and A2 of each layer and network error are calculated.

   A1=logsig (W1*P, B1);
   A2=logsig (W2*A1, B2);
   Error=T-A;

3) By using additional momentum method and learning speed self-regulation method, the error varieties D1 and D2 of each layer backward can be computed and so the modified values and the new weights of each layer. The blow software can be used to complete the above procedure.
If TSSE>SSE*err_ratio, mc=0; Tlr=lr_idec*lr;
Elseif TSSE<SSE, mc=momentum; Tlr=lr_inc*lr;
End

4) Now the sum of error square of weights modified is to be computed once gain.
SSE=sumsqr(SamOut-logsig (W2*logsig (W1*SamIn))) :

5) A check is done to see if SSE smaller than err_goal, and if is yes, the training is over; otherwise the training is go
on.

D. Network simulation and output

The images to be classified and preprocessed are lored into the trained BP neural network by means of Matlab, and then the feature classifications on the images are recognized using the memory ability according to the training and learning of samples.

IV. RESULTS AND ANALYSIS

The researching data is the scene panchromatic remote image preprocessed that intercepted the sub images of 1475*1310 size. The experimental data is shown in Figure 2.

The feature distribution in the studying area is obvious, so Figure 2 is divided into three types of farmland, resident area and vegetable land according to the actual investigation and the image interpretation by eye sighting.

Figure 2 is to be input into BP neural network, and the output results of training simulation are shown in Figure3. Figure 4 shows the network training curves, and it can be seen from the experimental conclusion that the network convergence speed is increase obviously by using the additional momentum method and the self-regulation method of learning speed to avoid the network fall into the local minimum value and achieved the ideal results.

![Figure 2. Image before classification](image1)

![Figure 3. Results of using BP neural network](image2)

According to the visual analysis, Figure 3 can factually reflect the actual situation of different features. But there are still some errors in partial resident and vegetable lands, the reason for this is result from the large similarity of both of spectrum characteristics. Besides, the misclassification in some degree caused from the affection of relativity of feature characteristics in the aspect of feature extraction.

The total precision and Kappa coefficient can be computed according to the confusion matrix.

Total precision=\(\sum a_{ij} / N=86.67\%\)

K= \((N \times \sum a_{ii} - \sum (T_j \times T_i)) / (N^2 - \sum (T_j \times T_i)) = 0.82\)

<table>
<thead>
<tr>
<th>classification</th>
<th>vegetable land</th>
<th>resident land</th>
<th>farmland</th>
<th>sum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetable land</td>
<td>23</td>
<td>4</td>
<td>1</td>
<td>30</td>
</tr>
<tr>
<td>resident land</td>
<td>7</td>
<td>27</td>
<td>1</td>
<td>30</td>
</tr>
<tr>
<td>farmland</td>
<td>1</td>
<td>0</td>
<td>28</td>
<td>30</td>
</tr>
<tr>
<td>sum</td>
<td>31</td>
<td>31</td>
<td>30</td>
<td>90</td>
</tr>
</tbody>
</table>

Where, \(a_{ii}\) is the diagonal elements of confusion matrix, \(N\) the total number of all typical samples, \(T_j\) \(T_i\) the sums of the row i and column j of the confusion matrix. The total precision is 86.67\%, Kappa coefficient is 0.82 through the computation. It is obvious that the improved BP neural network can meet the need of remote sensing image classification in the classifying precisions.
V. CONCLUSION AND EXPECTATION

After a training of 300 times to a scene panchromatic remote image, it is shows that simulation output can factually reflect the feature of the original images by suing the momentum and self-regulation method of learning speed. It is also prove from the experimental analysis that the method can improve the training speed greatly on BP network and overcome the shortcomings of low training speed, network convergence being not easy and so on. In the experiment, some misclassifications appear on the vegetable and resident lands in some degree, which results from the similarity of diversity of image gray in the probability and statistics. Therefore, the processing should be carried through such as radiometric correction, shadow and noise eliminating and so on before the training samples of image are input into the network to enhance the separate among the several of features so as to reach the goal of the classifying precision improving.

REFERENCES


