Study on Inversion of Soil Salinity with Hyperspectral Remote Sensing

LIU Dandan, ZHANG Yujuan
Surveying and Mapping Engineering, Heilongjiang Institute of Technology, Harbin, 150050
Liudan19722003@yahoo.com.cn

Abstract: One experimental area in the city of DaQing in Heilongjiang province is took as an example to perform the quantitative inversion of soil salinity using Hyperion data in this paper. The inversion method of soil salinity using Hyperion data is discussed by the image preprocessing, the feature extraction and the establishment of BP neural network model. It gives a lot of help in soil survey system and promoting the development in quantitative retrieval of soil salinity. Meanwhile, this model provide reference for solving other non linear problems. If we have profit train data, this model can do the retrieval of other parameter.

Keywords: soil salinity, Hyperion data, inversion, BP neural network model

1 Introduction

Quantitative remote sensing is one of the most important direction of remote sensing science development. In the methods of quantitative inversion, neural network model can realize any nonlinear mapping between input and output and generalization function. Complicated nonlinear relation exists in soil salinity and image spectrum information, hyperspectral data provides continuous narrowband spectrum information which provides powerful tools to soil assessment and monitoring. Dehaan and others have studied on soil salinization evaluation by using hyperspectral data[2, 3, 4]. Currently, surface parameters quantitative inversion is actively made by experts at home and abroad through hyperspectral data, the methods In many fields of research are mature, such as the research on vegetation index, vegetation leaf area index, dry matter accumulation quantity, water pollution etc. But the research on soil salt content are rare, especially the research of how to accurately inverse soil salinity In small sample circumstances. Soil salinity inversion is more complex, not a simple linear problem[5]. On the basis of image preprocessing and feature selection, the inversion method of soil salinity using Hyperion data is discussed by the establishment of BP neural network model. This paper probes into the process and methods of establishing hyperspectral data Hyperion soil salinity inversion model.

2 Materials and Methods

2.1 Sample data acquisition and processing
The SongNen plains in Heilongjiang province belongs to arid and semi-arid climate zones, there is 373 million hm² salinization land, it is one of the 3 biggest saline-alkali on regional distribution in the world[6].The experimental area is located in the southwest of the cities of Zhaozhou and Zhaoyuan. because saline-alkali distribution is uneven, The district's image had been interpreted and the wild sampling route combined with statistical data had been determined before field sampling. To minimize vegetation factors influence on study results, the 200 samples which are 0 ~ 5cm thickness surface soil were collected in April, at the same time the plane coordinates and elevation data of the sampling points were surveyed.

2.2 Data pretreatment

Source: The Doctoral Research Fund Program of Heilongjiang Institute of Technology.
Using visual method, 176 bands was selected from 242 bands. Data preprocessing includes radiation correction, precise correction of geometric distortion, denoising, removal stripe, etc. Surface are assumed to approximate lambertian reflector and surface features reflectivity and DN value is linear relationship, regression analysis method and measured spectrum value were used in radiation correction, because the study area topography is flat, second polynomial function was adopted to realize precise correction of geometric distortion and error was controlled in 0.5 pixels.

2.3 Imaging and soil salinity correlation analysis
Single-band spectral reflectance and soil salinity was analyzed through correlation coefficient, the results (Figure1) showed that soil salinity correlation coefficient in visible and near-infrared wavelengths was larger and band with better correlation concentrated in 500-900nm. After Principal Component Analysis (PCA), Independent Component Analysis (ICA) and Maximum Noise Principal Component Transformation were finished, the correlation between feature image and actual measurement data of soil moisture content was analyzed, the results showed that after dimensionality reduction mapping, correlation was not improved significantly. So, experience statistic model was built through the band with the biggest correlation coefficient, and neural network model was found through data from the original 176 band.

![Figure1 The scatter plot of correlation coefficient of single-band and soil salinity](image)

2.4 BP network model design
There were 200 samples in this study, to ensure accuracy, BP neural network model was 4 layers, the number of double-hidden layer node could be calculated according predecessors’ formula:

\[ n = \sqrt{n_i + n_o + a} \]  

n: number of hidden layer node; \( n_i \): number of input node; \( n_o \): number of output node; a: constant during 1 to 10

In order to overcome interference from a few unusual values, unusual values should be removed after statistical analysis and before modeling. Neural network model was shown in figure 2

![Figure2 Neural network model of four layer](image)

3 transfer functions were selected, Log-sigmoid, Tan-sigmoid and linear function, some training algorithms were used, they were traingd, traingdm, traingdx, trainrp, traincfg, traincgp, traincgb,
trainscg, trainbfg, trainoss, trainlm etc, the test result was shown through calculating samples RMSE of measured value and simulation value and correlation coefficient. Through the design and MATLAB7.1, BP neural network model was built, practiced and simulated, at last, soil salinity inversion image was got. Shown as Figure 4, hidden and output layer transfer function is purelin, training function is trainbr, the result of some area soil salinity inversion compare. Image(a) shows the area and image(b) is soil salinity inversion image.

2.5 Experience statistic inversion model
Through analyzing the correlation between hyperspectral data single band and soil salinity, the band with the biggest correlation was got. According to the band, BP neural network model, LIN, QUA, CUB curve experience statistical models were built.

3 Results and Discussion

3.1 Choose different transfer function and training function
Setting goals error is 0.001, when hidden layer transfer function is Log-sigmoid and output layer transfer function is purelin, trainlm convergence speed is fast, RMSE decreases gradually along with the increase of training frequency, when frequency increases to 8, RMSE decreases to 0, in this case, the model correlation coefficient is 0.724, data and the model are fit best. When hidden layer transfer function is Tan-sigmoid and output layer transfer function is purelin, trainlm convergence speed is fast, when frequency increases to 7, RMSE decreases to 0, in this case, the model correlation coefficient is 0.733, data and the model are fit best. When hidden layer transfer function is purelin and output layer transfer function is purelin, in order to fit data and the model best, trainbr function should be selected.

3.2 Precision analysis among different inversion model
Setting hidden layer transfer function is Log-sigmoid, output layer transfer function is purelin, training function is trainlm and hidden layer node number is 20, all models actual precision values can be calculated through the formula:

$$\xi = (1 - \frac{|y - \hat{y}|}{y}) \times 100\%$$

Table 1 lists actual precision values of different models inversion soil salinity and models correlation coefficients, it shows that the actual precision value of BP neural network model is higher than the actual precision values of experience statistic models.
Table 1: Precision of models

<table>
<thead>
<tr>
<th>Model type</th>
<th>BP neural network model</th>
<th>LIN</th>
<th>QUA</th>
<th>CUB</th>
</tr>
</thead>
<tbody>
<tr>
<td>actual precision %</td>
<td>80.69</td>
<td>46.56</td>
<td>51.35</td>
<td>51.21</td>
</tr>
<tr>
<td>correlation coefficient</td>
<td>0.724</td>
<td>0.483</td>
<td>0.488</td>
<td>0.488</td>
</tr>
</tbody>
</table>

4 Conclusion

1) Neural network model has great advantage to simulate the complex relationship between remote sensing image and soil salinity. Through BP Neural network model and hyperspectral data, inversion soil salinity is feasible under the situation of small sample data, the model can improve precision values.
2) Neural network has strong nonlinear fitting ability, can map complicate nonlinear relation, but it is lack of data interpretation capabilities.
3) J.F arifteh [9], etc have compared and analyzed PLSR and artificial neural network method, so this paper suggests that PLSR can be used to predict soil salinity. The research on quantitative inversion based on neural network remains to be further.

References