Study on the Framework of Soil and Water Conservation Analysis and Evaluation System Based on L-M Neural Network Algorithm

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Abstract

Soil and water conservation analysis and evaluation system is a theoretical model for the analysis and evaluation of the contribution of various soil and water conservation measures in the region. This research empirically analyzed the present situation of water and soil conservation in the gully area of the Loess Plateau by soil and water conservation analysis evaluation system. With the optimized neural network model of L-M algorithm, it can improve the more convenient theoretical model for the analysis and processing of water and land resources information. The soil and water conservation analysis and evaluation system can fully evaluate the feasibility of water and soil conservation planning in the research area and reification measures are put forward according to the disadvantages of the design. Under the condition of combining the influence mechanism of other environmental factors, objective data indexes are provided for soil erosion, so as to fully grasp the factors and directions of the ecological environment changes in the surveyed areas and provide a scientific basis for the future soil and water conservation planning in the region.

Keywords: BP Neural Network, L-M Algorithm, Gauss-Newton Method, Soil and Water Conservation, Evaluation System.

1. RESEARCH BACKGROUND

1.1 Literature review

Soil and water conservation analysis is an empirical investigation of the situation of water and soil resources in the surveyed areas. The survey data are objective data that directly reflect the ecological environment in this area, which can provide a theoretical basis for the comprehensive management of environmental resources. After collecting this data of ecological resources, the operation model of BP neural network system is often used to analyze the water and soil loss situation (Wang and Ou 2013). Although used for local small-scale changes, BP neural network model has the effect of higher data parameters and can show the ecological resources index of a certain area, it can’t make a comprehensive assessment of its global performance. Therefore, there are some drawbacks in practical application, which can’t objectively reflect the changing conditions and expected directions of land and water resources in the regional ecological environment (Qian et al., 2013). Therefore, in view of the soil and water conservation analysis and evaluation model, a more effective operation model should be adopted in order to improve its substantive evaluation results.

1.2 Research objective

Commonly used methods for evaluating the benefits of soil and water conservation include AHP, fuzzy comprehensive evaluation and gray system assessment, which have their own advantages and disadvantages, but they also do not show the common problems of soil and water loss (Gui et al., 2016). Therefore, based on the optimization model of BP neural network, L-M neural network algorithm is designed this study, which is based on gradient algorithm and Gauss-Newton algorithm and is further improved (Xue et al., 2011). With the gully area of Loess Plateau as the research object, the data survey and analysis results were compared. By comparing with other algorithms, it is found that the L-M neural network algorithm has a more optimized training process and can be compared and optimized for very small operation coefficients. Therefore, it can be confirmed that the L-M neural network algorithm can provide a scientific, objective and reasonable index evaluation basis for the design of soil and water conservation analysis and evaluation system and further improve the theoretical framework of soil and water conservation analysis and evaluation system.
2. BP NEURAL NETWORK MODEL THEORY FRAMEWORK BASED ON L-M OPTIMIZATION ALGORITHM

2.1 Soil and water conservation analysis and evaluation system framework

Without a proper plan of soil and water conservation work in the area, highly targeted soil and water conservation measures will not be able to successfully carried out and will more easily cause the waste of ecological resources and damage to the ecological environment. Therefore, the scientific guidance of soil and water conservation management, conservation of water and land resources, and improvement of regional ecological environment need to be based on the minimum investment and the maximum ecological benefits (Yu et al., 2010). Therefore, the promotion of sustainable economic and social development can be achieved, and ensure the maximum utilization of water and soil resources and the protection effect. Thus, most of the research results are integrated to design a soil and water conservation analysis and evaluation system in this research, and the framework is shown in Figure 1.

![BP Neural Network Model Frame Structure Based on l-m Optimization Algorithm](image)

**Figure 1.** BP Neural Network Model Frame Structure Based on l-m Optimization Algorithm

2.2 Advantages of L-M algorithm

Proposed by scientists Rumelhart and McClelland in 1986, bp neural
Network concept is a multi-layer feedforward neural network trained in accordance with the error back propagation algorithm and is the most widely used method of neural network computation. Artificial neural network can use a large number of simple information to process unit connected to the neural network and further used to describe the more complex environment model. Then the single hidden layer simulation of BP neural network can show the law of development closed to the actual situation. However, due to the rapid decline of the error gradient of BP neural network, the BP algorithm processes the remote sensing information slowly (Ding et al., 2010). Then in simulating the problem of soil and water loss in the natural environment, it is likely to cause the objective phenomenon within insufficient forecast value. Therefore, it is necessary to provide the actual operation rate of the BP neural network model by the L-M optimization algorithm in order to simulate a more realistic dynamic information environment. As to the shortage of BP neural algorithm, a variety of algorithm improvements has been proposed in the academic research, such as heuristic algorithm, variable learning rate algorithm, rebound algorithm. Meanwhile, in order to improve the local extreme value of BP algorithm, it can also be optimized by global algorithm, genetic algorithm and simulated annealing algorithm. However, the computational cost of the above algorithm is high, so it is not conducive to expanding the investigation and analysis of water and land resources in a larger space. Combing the Gauss Newton method with the gradient descent method, the LM algorithm can enhance the authenticity and computational efficiency of the computation results and thus has higher application value and can exert a higher value in the investigation and study of soil and water resources Operational effects.

3. IMPROVED FUNCTION MODEL OF L-M ALGORITHM BASED ON GAUSS - NEWTON METHOD

3.1 Gradient descending method

Called the steepest descent method, for there are no constraints in the solution process, the gradient descent method is the easiest way to solve the problem. Although it is not practical now, many effective algorithms are improved and corrected based on it. Plus, the environmental parameter calculation mechanism proposed in this study is also operated by the principle of gradient descent (Li and Pan, 2012). With negative gradient direction as the search direction, the closer to the target value, the smaller the step size, the slower the relative progress. Therefore, if \( W(k) \) means to iterate the vector of network weights for the \( k \) time, and \( M \) represents the new weight vector, then set the operation rule as \( W(k+1) = W(k) + \Delta W(k) \). Then set the target error function as:

\[
E(W) = \frac{1}{2} \sum_{i=1}^{N} e_i^2(W) = \frac{1}{2} \sum_{i=1}^{N} (t_i - O_i)^2
\]  

(1)

In this formula, \( t_i, O_i \) represents the actual value and the expected value of the error, and \( N \) represents the vector dimension, set \( e(w) = [e_1(w), e_2(w), \ldots, e_n(w)]^T \), then the relevant variables in the vector dimension can be expressed as:

\[
\nabla^2 E(W) = J^T(W)J(W) + S(W)
\]

(2)

\[
S(W) = \sum_{i=1}^{N} e_i(W)\nabla^2 e_i(W)
\]

(3)

3.2 Gauss-Newton method

The Gauss-Newton method has the advantages of fast convergence and high accuracy. The second iteration makes the accuracy as high as 99.97% and the correlation index also increases obviously. Theoretically, it can be proved that after Gaussian-Newton iteration, the estimated regression coefficient will approximate the best regression coefficient to be estimated, minimizing the sum of squared residuals, thus obviously overcoming the shortcomings of the least square method. The disadvantage is the large amount of computation, but in the continuous development of computer technology, the hardware configuration can be continuously renewed to meet the memory capacity requirements and achieve the optimal configuration of stored data and information content (Zhang et al., 2015). In the first formula and the second formula, \( \nabla^2 E(W) \) can be expressed as the error function matrix model with the \( S(W) \) weight as the evaluation direction. Newton's computing model can be set as:

\[
\Delta W = -[\nabla^2 E(W)]^{-1}\nabla E(W)
\]

(4)

When nearly close to the conventional solution set, the constraint condition of this model is \( S(W) \equiv 0 \), and the calculation rule of setting it as Gauss-Newton method is:
\[ \Delta W = -[J^T(W)j(W)]^{-1}J^T(W)e(W) \] (5)

### 3.3 L-M operational model

LM algorithm can be easily implemented in practice. The key model functions can be linearly approximated in the domain of their estimated vector, and the second-order derivative term can be neglected to transform into the linear least-squares problem, showing higher speed of convergence (Ju and Cai, 2015). The LM algorithm is a kind of the trust region algorithm. In the calculation process, it is required to minimum value of a function in the optimization algorithm, and to decrease the objective function with iterative method of each step. From the initial point, setting a reliable maximum displacement firstly, and then in an area with the current point as the center, the displacement index as the radius, by finding the optimal point of an approximate function (the second) of an objective function, it aims to get the real displacement. After the displacement is obtained, the targeted function value is calculated again. If the decrease of the targeted function value satisfies a certain condition, then it indicates that the displacement is reliable and it is suitable to calculate iteratively according to this rule continually. If it can’t make the decrease of targeted function value to meet certain conditions, you should reduce the scope of the trust region, and then summed up the type of collection to be resolved. The L-M algorithm is based on improved algorithm of Gauss - Newton, and the theoretical model is:

\[ \Delta W = -[J^T(W)j(W) + \mu I]^{-1}J^T(W)e(W) \] (6)

In this formula, the scale factor \( \mu \geq 0 \) is constant, and represents the unit matrix. In the actual operation, it can also be used as a tentative parameter to give its value space (Luo et al., 2016). Then the error index function level can be found. Relatively speaking, the increase of \( E(W) \) follows the increase of \( \mu \). On the contrary, the decline of \( E(W) \) will follow the decrease of the coefficient. The improved algorithm by L-M is essentially based on the evaluation of computational complexity. When the algebraic equations have been shown to have extremely high weights in the network, the number of iterations will also increase significantly, and the amount of storage and computation will be relatively increased. Also, the improved algorithm of L-M can avoid the practical problem of low iterative efficiency and improve its overall performance based on the calculation accuracy.

### 4. EMPIRICAL STUDY RESULTS OF SOIL AND WATER CONSERVATION BASED ON L-M NEURAL NETWORK ALGORITHM

#### 4.1 Empirical data on soil and water resources

Soil and water loss is the most important ecological and environmental issue in our country at present. It not only relates to the adjustment of ecological and environmental protection measures in our country, but also affects the development of industrial and agricultural production. Therefore, further solving the problem of the loss of water and soil resources is also the most important ecological resource development issue at present. Among them, the area with the most serious soil erosion is in the Loess Plateau in China, which is also one of the areas with the most serious soil erosion in the world (Li et al., 2016). The loess plateau gully area is located in the southern loess plateau, mainly including the Weibei dryland gully area of the Loess Plateau, Longdong loess plateau gully area and the Yellow River Valley Gully area in Shaanxi and Shaanxi province. Compared with the hilly area of the Loess Plateau in the middle reaches of the Yellow River, the soil types and the depth and extent of ravines in these two areas are almost the same. The loess plateau gully area is characterized by wide and flat tableland, small gully densities and slope gradient, and therefore, soil erosion intensity is relatively small. However, with the low latitude in the area, good the climate conditions, the abundant agricultural climate resources, the population density is also the highest in the Loess Plateau region. Therefore, a number of comprehensive factors have aggravated the human activities causing damage to the environment so that soil and water loss in the gully area of Loess Plateau is more and more serious. Then a comprehensive survey of the conservation of soil and water resources in this area and the summarizing the more targeted governance measures relying on objective data are also the most important directions for land and water resources research at present. Therefore, based on the BP neural network of L-M optimization algorithm, this study investigated the water and soil resources for a small part of the area and based on 800 pixels without cloud shadow, the image quality is guaranteed. The survey data in this area mainly include six items: water area, forest, wetland, building, farmland and bare land (Luo and Huang, 2015). The survey data is shown in Table 1.
### Table 1 Empirical Data of Soil and Water Conservation Analysis Based on L-M Neural Network Algorithm

<table>
<thead>
<tr>
<th>Projects</th>
<th>Reference data</th>
<th>Total</th>
<th>% User accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>waters</td>
<td>forest</td>
<td>wetlands</td>
</tr>
<tr>
<td>waters</td>
<td>21</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>forest</td>
<td>0</td>
<td>62</td>
<td>0</td>
</tr>
<tr>
<td>wetlands</td>
<td>1</td>
<td>1</td>
<td>37</td>
</tr>
<tr>
<td>buildings</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>farmland</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Bare land</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>total</td>
<td>22</td>
<td>67</td>
<td>39</td>
</tr>
<tr>
<td>Production accuracy %</td>
<td>99.26</td>
<td>95.27</td>
<td>93.58</td>
</tr>
</tbody>
</table>

### 4.2 Evaluation of network training effect

A basic experience of soil and water conservation work is comprehensive planning and comprehensive management. Even though the comprehensive analytical data of the area are obtained, the calculation accuracy will not be met. It is also important to further assess the actual development conditions and the existing status of many resources. Therefore, based on the optimization algorithm of L-M, data related to the index sequence such as watersheds, forests, wetlands, buildings, farmland and bare land are collected in this study (Zhou et al., 2015).

With the comprehensive utilization of water and land resources as an evaluation item, development and existing problems are evaluated. Similarly, it is needed to validate comparative analysis data in L-M optimization algorithm to ensure that the theoretical model of the algorithm is suitable for the environmental investigation and evaluation of water and soil resources. Therefore, in order to compare the advantages L-M algorithm has in network training model, this study uses the heuristic algorithm as a reference comparison program. The parameters of the heuristic algorithm are set as follows: the initial learning rate is 0.2, the momentum term 0.9, the reduction coefficient 0.7 and the increasing coefficient is 1.06. The heuristic algorithm is used to demonstrate the network training results, and with the hidden node (10-30) as the graded increasing condition, the function error is controlled within 10-4 in the iterative calculation within 20,000 times (Wang and Fang, 2010).

After calculation and comparison, it is found that the LM algorithm has higher computational efficiency, in which the number of hidden nodes is 12, the time in the training curve is 105.311S, the initial parameter is 0.001, the descending coefficient is only 0.1, and the rising coefficient reaches 10, and the minimum gradient mode is less than 10-10. Then if the training network is corresponding to the classification test results, the highly accurate land and water resources distribution will be got. The network training curve iterations number is showed in Figure 3.

![Figure 2. The Development Trend of Network Training Curve of Iteration Times](image)

Through the comparison of the above two data indicators, it can be found that the L-M algorithm has optimized the data amount of the collected samples and can achieve the substantial effect of improving the operation efficiency. At the same time, the LM neural network algorithm has a more optimized training process, which can be used to compare and optimize very small operation coefficients. Therefore, it can be proved that the LM neural network algorithm can provide a scientific, objective and reasonable index evaluation for the design of soil and water conservation analysis and evaluation system Basis, and then improve the theoretical framework of soil and
water conservation analysis and evaluation system. Based on synthesizing the mechanism of other environmental factors, objective data indicators are provided for soil erosion, so as to fully grasp the factors and directions of ecological environment changes in the surveyed areas, providing a scientific basis for the future soil and water conservation planning in the region, achieving the targeted governance and conservation of resources.

5. CONCLUSION

In summary, the L-M algorithm, taking advantage of the global advantages of the gradient algorithm, is an improved model based on the Gauss-Newton method. In terms of evaluation index and evaluation effect, it is significantly superior to the traditional BP neural network algorithm. Moreover, if only Gaussian-Newton method is used for transportation, the convergence rate can’t be guaranteed, and the relative number of iterations is too small to reduce the calculation accuracy. Therefore, we need to optimize the neural network operation model by using L-M algorithm, so as to improve the convergence effect of Gauss-Newton method and ensure the stability of calculation results (He et al., 2016). However, there are many iterations in the L-M algorithm. Therefore, in the process of increasing the amount of computation, the memory capacity needs to be further increased to complete larger-scale water and land resources information collection. And the actual inspection of hidden nodes can also be stratified to optimize the calculation results and continue to be closer to the actual value of the effect. Therefore, in the evaluation system of water and soil resources, an optimization model of L-M algorithm should be adopted so as to improve the evaluation effect of water and soil resources and ensure to understand the ecological environment characteristics in different regions in time in order to formulate more targeted governance measures.

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