Berger Scientfic Press

Innovation & Technology Advances, 2023, 1(2), 25-31
https://bergersci.com/index.php/ita/index
DOI: 10.61187/ita.v1i2.37

Research on the evaluation system of green cabling of cables based on neural network

Lingqi Meng*

Shenyang University of Technology, Liaoyang 111003, Liaoning, China

*Correspondence: mlq17806096925@163.com

Abstract: This paper mainly focuses on the results of the virtual wiring of the supporting trailer line behind the shield machine, and on this basis, the construction of the green evaluation system of the three-dimensional path of the cable is explored based on the neural exploration, so as to evaluate the excellence of the constructed path, make a reliable and realistic evaluation of the path planning, make the experimental results more realistic, and improve the calculation efficiency of the algorithm. Finally, the algorithm is applied to the cable layout in 3D space and the example analysis is carried out, and the simulation results prove the feasibility and effectiveness of the experimental results. Finally, the AxureRP9 was used for system prototyping. The purpose is to build a prototype of the web version of the green wiring evaluation system that has been operated and has a wide range of applications.

Keywords: cable; shield machine; three-dimensional; green cabling; prototyping

How to cite this paper: Meng, L. Research on the Evaluation System of Green Cabling of Cables Based on Neural Network. Innovation & Technology Advances, 2023, 1(2), 25–31. https://doi.org/10.61187/ita.v1i2.37

1. Introduction

In this paper, the three-dimensional wiring of the cable of the shield machine circuit system is studied, and there are many factors affecting the cable path planning and the wiring problem is relatively complex, and the three-dimensional cable wiring of complex mechanical products has not yet formed a mature system for the three-dimensional wiring of the cable in China. The circuit of the shield machine is complex, and the safety and reliability of the wiring results should be ensured while studying the green wiring of the circuit system. At present, the main means of wiring at home and abroad is still through the mode of manual wiring, which mainly relies on the experience of wiring staff to wiring, which leads to serious deficiencies in the rationality of the quality of cable wiring, and the accuracy of the wiring results cannot be verified. There is a lack of a reasonable, unified and accurate evaluation system.

In order to ensure the quality of wiring and judge whether the wiring result meets the wiring requirements, it is necessary to establish a wiring evaluation system to accurately evaluate the final wiring results, which not only needs to rely on the experience of wiring experts, but also needs to collect data on key parameters that affect wiring, such as environmental factors, equipment safety, etc.; The establishment of a cable wiring result evaluation system can not only improve the R&D progress of products, reduce the interference of manual factors, but also reduce R&D costs and avoid the waste of resources such as cables. Therefore, the establishment of a reasonable green evaluation model has strong practical significance for the actual production.

2. Principles for the Construction of Green Evaluation System

In order to establish a set of scientific and reasonable wiring results evaluation system, it is necessary to fully implement the principles of comprehensiveness, scientific rationality, operability, comparability and independence.

2.1. Environmental friendliness

The evaluation system takes environmental friendliness as one of the core evaluation indicators. This includes the renewability, degradability and environmental impact of the cable. When selecting cables, choose materials that meet environmental standards, such as low-volatile materials and lead-free materials.

2.2. Resource utilization

The evaluation system should pay attention to the resource utilization rate of the cable system. Reasonable cable routing and reducing unnecessary cable lengths and cable quantities can improve resource utilization while reducing the demand for limited resources.

2.3. Comprehensiveness

The principle of comprehensiveness requires that the wiring result evaluation system is systematic and complete, and it is necessary to grasp the various influencing factors that affect the wiring results from a global perspective, and analyze the factors affecting the wiring results from various perspectives and levels. On the contrary, without a comprehensive evaluation principle, it is impossible to comprehensively and accurately evaluate the wiring results, and it is impossible to reflect the overall situation of the wiring of the shield machine circuit system.

2.4. Scientific rationality

The principle of scientific rationality evaluation is a key part of the whole wiring evaluation system, and it is the basic principle to ensure the accuracy and reasonableness of the evaluation results. Scientific rationality is mainly reflected in the following two aspects: first, the selection of influencing factors must follow objective facts; Second, the concept, meaning, calculation scope and calculation method of the same indicator must be unified and reasonable, so as to reduce the error in the evaluation process and the influence of competent factors on the entire evaluation results.

3. Determination of Evaluation Grades

3.1. Determination of evaluation grades

In this paper, the characteristics of the cable wiring of the shield machine are studied, and the mechanical properties, electrical properties, laying paths, and resource utilization rates of the cables in the laying process are comprehensively considered. Based on the principle of equal partitioning, the normalized data processing method was used to divide the evaluation grades of green wiring into five grades, as shown in **Table 1**.

Table 1. Evaluation grade of green wiring of the circuit system of the shield machine

Evaluation Rating	Ideal I	Good II	General III	Poor IV	Very Poor V.
Exponential R	R≥0.8	0.6≤R<0.8	0.4≤R< 0.6	0.2≤R<0.4	0.2<R

3.2. Green wiring evaluation method

In this study, when constructing the evaluation system, the analytic hierarchy process was used to summarize all aspects and links affecting the wiring of the shield machine, and the main aspects of the evaluation were determined [1,2]. Then, according to the characteristics of the main aspects, they are decomposed into sub-indicators one by one, and the sub-indicators are decomposed one by one according to the above principles to obtain each individual evaluation index. The optimal path of wiring is taken as the highest goal of the whole system, and the construction process of the evaluation index system is mainly considered in the following three aspects [3]: 1) According to the characteristics of green wiring, all aspects of the green wiring system of the whole shield machine are comprehensively understood and analyzed. 2) Based on the extended framework of the conceptual model, the evaluation indicators were selected. 3) Quantitative analysis of the selected indicators was carried out one by one to determine their characterization attributes to the system.

3.3. Construction of green wiring evaluation model

In order to ensure that the neural network has sufficient input sensitivity and good fitting to the samples, the X_i samples need to be dimensionless or normalized before network training, so that the values of each sample element are between [0,1]. There are different methods that can be used to dimensionlessly or normalize a sample, but here are four commonly used normalization methods, which are described below:

1) The sample of X_i can be normalized to between [0,1] using the following formula.

$$Y_{regression} = \frac{Y_i - Y_{\min}}{Y_{\max} - Y_{\min}} \tag{1}$$

where is the normalized value of the sample; Y_i is the value of the sample Y_{max} and Y_{min} are the maximum and minimum values of the sample element, respectively.

2) The following formula normalizes the sample of the X_i to [-1,1].

Where $\overline{Y}$ is the average value.

$$Y_{regression} = \sin\left(Y_i - \overline{Y}\right) \tag{2}$$

The following equation normalizes the sample of X_i to between [0,1].

$$Y_{regression} = \frac{\ln y_i}{trunc\left[Max\left(\ln y_1, \ln y_2 \cdots \ln y_n\right)\right]+1} \cdots\cdots (i=1,2,\cdots,n) \tag{3}$$

3.4. Establishment of green wiring evaluation system

The calculation steps of BP neural network are summarized as follows:

1) Enter N training samples $\left(X_k, X_k^*\right), k = 1, 2, \cdots N$.

2) To determine the large topology of the BP neural network, firstly, the number of layers of the network $L(L \geq 3)$ is determined. The number of nodes n in the input layer of the network is determined by the length n value of the input vector X_k of the X_i sample. The number of nodes m of the network output layer is determined by the length m value of the X_k^* of the X_i sample. The number of nodes in layer l is $n^l \bullet W^{(l)} = \left[W_{ij}^{(l)}\right] n^l \bullet n^{(i+1)} (l=1,2,\cdots,L-1)$ is defined as the connection right matrix between layer l and layer l+1.

3) Determine the X_i rate η and allowable error ε of the network, the number of initialization iterations t=1, and the serial number of the X_i sample k=1.

4) Select the kth X_i sample $\left(X_k, Y_k^*\right), X_k = \left(X_{1k}, X_{2k}, \cdots, X_{nk}\right)$, and so on.

5) If the X_k is calculated for forward propagation through the input layer input network, the output of each node in the input layer is:

$$O_{jk}^l = f\left(x_{jk}\right) \cdots\cdots (j=1,2,\cdots,n) \tag{4}$$

The inputs and outputs of each node of each layer are calculated layer by layer:

$$I_{jk}^l = \sum_i^{n^{(n-1)}} W_{jk}^{(l-1)} O_{jk}^{(l-1)} \tag{5}$$

$$O_{jk}^{l}=f\left(I_{jk}^{l}\right)\cdots\cdots\left(l=1,2,\cdots,n^{l}\right) \tag{6}$$

6) The output node error of the output layer (layer L) is calculated as follows:

$$\begin{cases} y_{jk}=O_{jk}^{(l)} \\ E_{jk}^{(l)}=\frac{1}{2}\left(Y_{jk}^{*}-Y_{jk}\right)_{2} \end{cases} \cdots\cdots(j=1,2,\cdots,m) \tag{7}$$

7) If the calculation result of each X_i sample of N meets the $E_{jk}\leq\varepsilon(1,2,\cdots,m)$, the learning X_i process ends; Otherwise, reverse error propagation is performed to modify each connection weight matrix [4].

8) Error backpropagation calculation. Modify the connection right matrix from Layer L-1 (Hidden Layer) to Layer L (Output Layer) as follows:

$$\begin{cases} \sigma_{jk}^{(l)}=-\left(Y_{jk}^{*}-Y_{jk}\right)f'\left(I_{jk}^{(l)}\right) \\ \Delta w_{jk}^{(l)}(t)=\eta\delta_{jk}^{(l-1)}O_{jk}^{l} \\ w_{jk}^{l}(t+1)=w_{jk}^{(L-1)}(t)+\Delta w_{jk}^{(L-1)}(t) \end{cases} \cdots\begin{pmatrix} j=1,2,\cdots,m \\ i=1,2,\cdots,n^{(L-1)} \end{pmatrix} \tag{8}$$

Modify the connection weight matrix between each hidden layer in reverse layer by layer:

$$\begin{cases} \sigma_{jk}^{(l)}=-f'\left(I_{jk}^{(l)}\right)\sum_{i=1}^{n}{}^{n-1}\delta_{qk}^{(l+1)}w_{jq}^{(l)} \\ \Delta w_{jk}^{(l-1)}(t)=-\eta\delta_{jk}^{(l-1)}O_{jk}^{(l-1)} \\ w_{jk}^{(l-1)}(t+1)=w_{jk}^{(L-1)}(t)+\Delta w_{jk}^{(L-1)}(t) \end{cases} \cdots\begin{pmatrix} l=1,2,\cdots,m \\ j=1,2,\cdots,n^{(l)} \\ i=1,2,\cdots,n^{(L-1)} \end{pmatrix} \tag{9}$$

9) Let k=k+1, t=t+1, turn to step (4).

4. Establishment of a Green Wiring Evaluation

In this paper, a green wiring evaluation system for shield machine circuit system based on BP neural network [5,6] is prototyped, and it is expected that the system users can realize the basic human-computer interaction and related functional requirements.

System prototyping refers to an initial form of the software system to be developed or delivered, in this form, the software system has an initial interactive interface or basic functional modules, and a prototype with a high degree of restoration and clear information architecture can make it easier for users to understand the scheme concept of the shield machine circuit system green wiring evaluation system. In this article, the Axure RP9 is used for system prototyping. The purpose is to build a prototype of the web version of the green wiring evaluation system that has been operated and has a wide range of applications. The advantage of this prototype is that it is possible to evaluate the wiring results of the shield machine by importing data anytime and anywhere.

In terms of demand analysis, the designed system prototype needs to include four aspects: user login, basic information of the shield machine circuit system, evaluation index data display and output evaluation grade. Firstly, the functional framework of the evaluation system is determined according to the design requirements, the relevant interfaces are made in Axure RP and functional modules are added to it, and then the different interfaces are designed interactively according to the logical relationship between the functions. The prototype design of the green wiring evaluation system based on BP neural network circuit system is divided into four interfaces, which are the login page, the basic information page, the index data page and the evaluation result page. **Figure 1** below shows the login page.

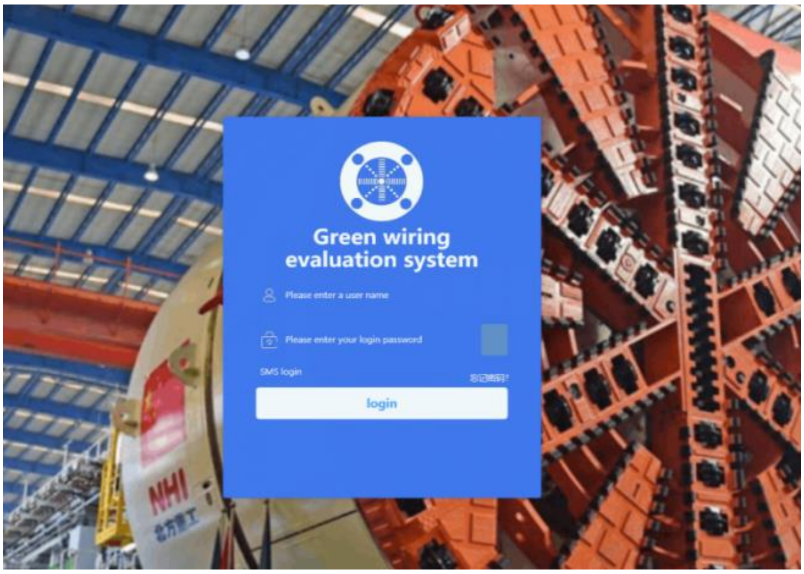

Figure 1. Login page.

As shown in **Figure 1**, the HTML file generated by the user login page is set up in two modes: password login and SMS is Login, Anderte, Interlac, Tion, Modbent, "Lokin" Bartonis designed to open the basic information page as shown in **Figure 2** in the current window when the mouse is clicked.

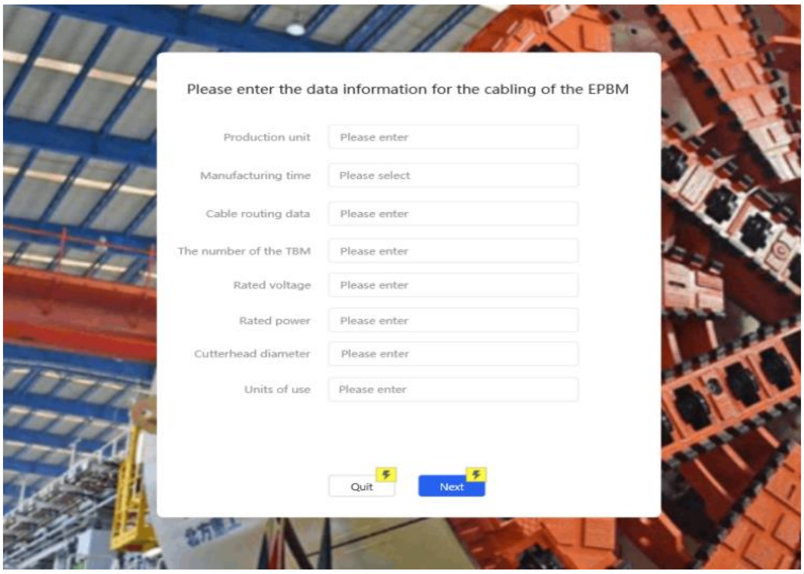

Figure 2. Basic information page.

The main function of the basic information page is to enter the necessary information of the circuit system wiring of the shield machine to be evaluated, including the manufacturing unit, the manufacturing date, the cable wiring data, the rated voltage, the rated power, the cutterhead diameter and the unit used, and the interaction mode of the "Next" button is designed to enter the index data page as shown in **Figure 3** in the current window, and click "Exit" to return to the userlogin interface.

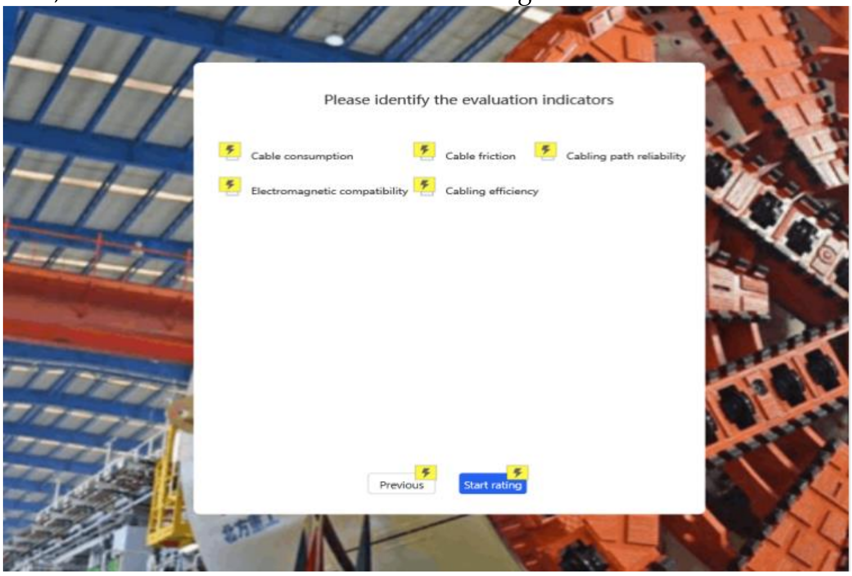

Figure 3. Metric data page

On the evaluation results screen shown in **Figure 4**, the "Exit" button is designed to interact in such a way that it returns to the login page in the current window.

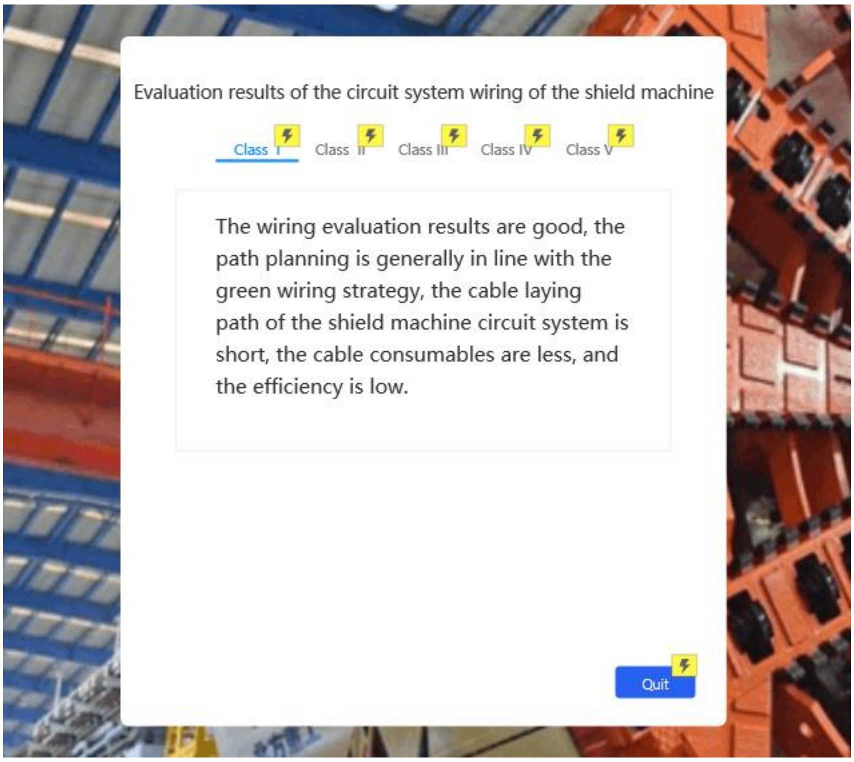

Figure 4. Evaluation results display page.

The evaluation results of the green wiring of the shield machine circuit system are divided into five levels: I., II., III., IV., and v., and different tab windows will be displayed according to different safety levels, for example, Figure 4 shows that the safety level of the current green wiring evaluation results of the shield machine circuit system is II.

5. Conclusion

In this paper, a neural network model is successfully built to evaluate the green wiring results of the shield machine circuit system, and the evaluation is successful, and finally the green wiring evaluation system of the shield machine circuit system based on BP neural network is prototyped, and the initial system prototype is designed.

References

1. Song, Q. Research on three-dimensional path planning technology of electromechanical products cable. Nanjing, Nanjing University of Aeronautics and Astronautics, 2018.
2. Wang, F,. Liao W., Guo Y., et al. Three Dimensional Space-wiring Technology for Cable Harness Based on Multi-scale Chaotic Mutation Particle Swarm Optimization Algorithm. Journal of Mechanical Engineering, 2017, 53(09): 144-156. https://doi.org/10.3901/JME.2017.09.144
3. Zhao, W., Xu M,. Zhang J., et al. Application of BP Neural Network in Mine Ecological Security Evaluation. Coal Technology, 2019, 38(01): 172-175. https://doi.org/10.13301/j.cnki.ct.2019.01.059
4. Yu, L., Shi F., Wang H., et al. MATLAB intelligent algorithm 30 case analysis. Beijing: Beihang University Press, 2015.
5. Xiao, L. Improvement of BP Xi algorithm and its convergence speed. Yinshan Academic Journal(Natural Science Edition), 2003, (01): 38-39. https://doi.org/10.13388/j.cnki.ysajs.2003.01.086
6. Xu, F. Identification of FPGA cost of the resources. Xi'an, Xidian University, 2014.