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RESEARCH PAPER

# A Neural Network Model for Expressway Investment Risk Evaluation and its Application

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**Abstract:** Investment risk evaluation of expressways plays a significant role in the sustainable development of expressways. A consideration of the inconsistency between operation accuracy and operation efficiency of the traditional quasi-3-layer BP neural network evaluation model is first established. This paper proposes and designs a variable-structure neural network model in the random re-linking process from the input layer neurons to the hidden layer neurons. Then, the model acquires the hidden layer to the output layer from the angle of structural optimization. Secondly, in view of the characteristics of the Chinese expressway investment, this paper develops an expressway project investment risk evaluation index system. Furthermore, a design of the expressway project investment risk evaluation model is completed based on the variable-structure neural network of the re-linking random process. In addition, the model has been verified with ten Chinese expressway projects. The risk evaluations have been conducted for four of the ten expressway projects. The research result shows that the average relative error predicted with such model is 1.91% and the maximum relative error is 2.63%.Therefore, the prediction result is deemed suitable.

**Key Words:** highway transportation; highway; neural network; variable structure; risk evaluation; system engineering.

## 1 Introduction

The expressways of China have such problems as: low operation efficiency, high toll costs, unorganized management, severe waste, high investment cost, and financial problems. Many projects even have very severe bank financing risks and hidden local fiscal difficulties [1]. Research has been conducted on expressway investment risk evaluation; for example, Wang Z G, *et al*[2] developed the ambiguous comprehensive evaluation model for expressway investment risks with the hierarchy analysis method and the ambiguous comprehensive evaluation method; Gao X, *et al*[3] identified the risks existing in expressways' applying asset securitization for financing and established the risk evaluation index system. The system evaluates risks with the improved hierarchy analysis method. Tian S B, *et al*[4] established the control interval and memory model to evaluate expressway investment risks. The factors affecting expressway investment risks are numerous and complicated. It is difficult for the traditional risk evaluation methods to effectively meet the demand on soundness and accuracy of expressway investment risk evaluation. Therefore, seeking a new method suitable for expressway investment risk evaluation is of practical and immediate significance.

The neural network is an engineering system that simulates the structure and intelligent action of the human brain on foundation of understanding the human brain tissue and operating mechanisms. Wherein, the most frequent forward neural network is the BP neural network, which is a multi-layer feed neural network based on an error back propagation algorithm. The BP neural network has such advantages of: self-organizing learning, high non-linear mapping capability, generalization, and error tolerance. A worthy result has been achieved for many problems that cannot be solved with the traditional information processing method after the neural network is adopted. In particular, the risk evaluation field, and the neural network evaluation method has been widely applied and has achieved active results. For example, Lou W G[5] applied the neural network into hi-tech project risk evaluation; Cui Weifang, *et al*[6] introduced the artificial neural network modeling method and

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established the agricultural hi-tech investment risk evaluation model based on BP neural network; Chen J H, *et al* [7] summarized and analyzed many factors affecting metal mine investment, established a scientific mine investment evaluation system. Also, development of the metal mine investment risk evaluation mode by combining fuzzy theory and neural network was conducted.

However, the traditional neural network model has the contradiction between operation accuracy and operation efficiency. This paper, in accordance with the neural network model in artificial intelligence and mode identification, has raised a new idea. With project historical data in combination with various technical indices as input values, and the various indices the project evaluation is based on as output values. Overall, this improves the structure of the traditional neural network evaluation model. Thus, it establishes a variable-structure neural network model and uses the same into expressway project risk evaluation.

## 2 Improved BP Neural Network and Algorithm

BP neural network consists of neurons and connective weighs among neurons and may be divided into the input layer, the hidden layer (multiple possibly) and the output layer. It belongs to the learning algorithm with tutor (the error back propagation algorithm) [8]. The structure and learning principle are shown in Fig. 1 below.

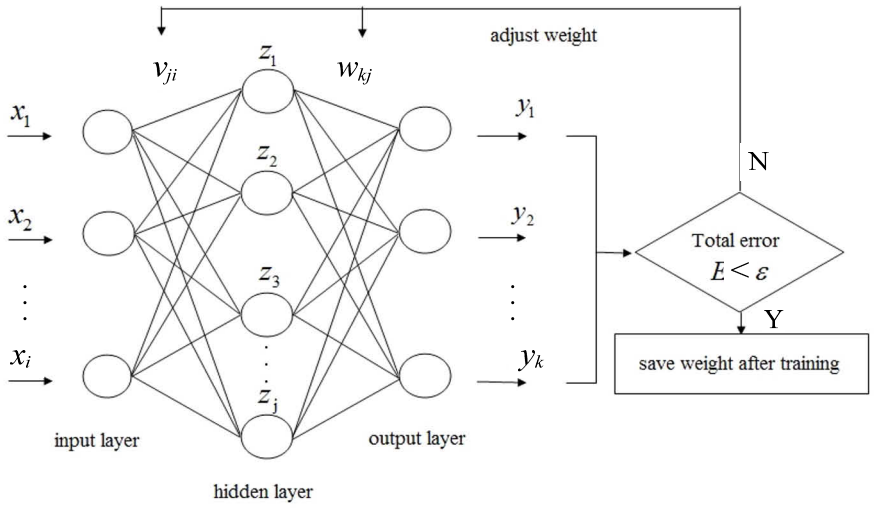


Fig. 1 Schematic diagram of structure and learning principle for BP neural network

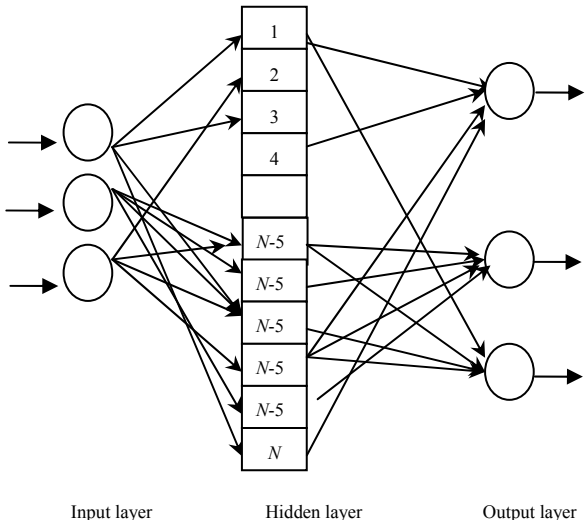


Fig. 2 Topology of quasi-BP neural network after random re-linking process

With respect to the quasi-3-layer BP neural network, this paper, from the angle of its structural optimization, has brought forward the random re-linking process from the input layer neurons to the hidden layer neurons and from the hidden layer to the output layer. Fig. 2 shows the topology of the quasi-BP neural network of $C$=4 after the random re-linking process. Through the structure's self-organizing learning process and with the random re-linking learning algorithm[9], the operation accuracy of BP neural network has been improved. The detailed algorithm is described as follows:

The weight between the hidden layer and the output layer on the $n$th step of the training and learning process has the following circumstances:

(1) In proper order, check every neuron $i$ on the output layer and take the neuron of every hidden layer connected as $j \in [0, C]$;

(2) Suppose $\xi_1 \in [0, 1]$ is a random value;

(3) If

$$\xi_1 < \frac{p_1 E}{w_{ij}}$$

then disconnect the end of such link connected with the