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Application of learning vector quantization neural network in the financial failure prediction

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ABSTRACT

Effective prediction of financial failures has been of great importance to Chinese listed companies because it can exert a big influence upon financial decisions to be made by investors, creditors and banking officers. For this purpose, neural network method has been introduced, and it has become a hot spot in this domain.

LVQ (Learning Vector Quantization) neural network method is adopted to set up a prediction model of financial failure in accordance with latest financial data of 14 listed companies. Repeated training and learning of the sample brings LVQ out. A comparison between LVQ and traditional BP (Back Propagation) has proved that LVQ algorithm has a higher prediction accuracy, which indicates that LVQ neural network method will enjoy good application prospect in the field of financial failure prediction.

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KEYWORDS

LVQ;
Neural network;
Financial failure;
Prediction.

INTRODUCTION

Financial failure is also known as financial difficulties, and the most serious financial difficulties is the enterprise bankruptcy. When an enterprise has no ability to perform the contract, to pay interest and repay the principal creditor, the enterprise will face financial failure. In fact, the enterprise sinking into financial distress and bankruptcy is a gradual process, most of the enterprise financial failure is composed of abnormal financial situation to deteriorate, eventually lead to financial failure or bankruptcy. Therefore, the enterprise's financial failure not only have aura, and it is predictable. With China's accession to the WTO, the financial banking is become more and more competition. Correctly predict

enterprise financial failure has an important practical significance on protecting the rights and interests of investors and creditors, preventing financial crisis for the operator, monitoring the quality of listed company and securities market risk for the government management department.

This paper mainly studies the prediction method based on the failure model of LVQ competition artificial neural networks in the financial, outlined the basic principles of financial failure and the concept of LVQ neural network. Regarding the financial failure prediction problem as a classification problem with the learning vector quantization network provided by Matlab7.0 neural network toolbox.

LVQ NEURAL NETWORK ALGORITHM

Introduction to the LVQ Neural network algorithm

LVQ Neural network has many advantages, for instance, a good network performance, fast training speed, less number of neurons, high recognition rate, simple network structure, and does not require the input vectors are normalized, orthogonal, only need to direct calculation between the input vector and the competitive layer distance, which can complete very complex classification through the interaction of internal unit, it is also very easy to design conditions of various complex dispersed domains converges to the conclusion.

LVQ network, so to speak, therefore, has the very good model classification features. Designers do not need to construct complex in the process, even nonlinear processing function to construct. In addition, the LVQ network shows stronger than BP network in fault tolerance and robustness, and it is not easy to lead to the collapse of the system.

LVQ network Algorithm principle

LVQ network learning rules

Before the introduction of network learning rules, first defines a variable. Assuming the input vector input layers for

$$X = (x_1, x_2, \dots, x_M) \tag{1}$$

Of them, M is the number of input neurons.

The connection weight matrix between input layers and competition layers is

$$W^1 = (w_1^1, w_2^1, \dots, w_p^1) \text{ \& } w_i^1 = (w_{i1}^1, w_{i2}^1, \dots, w_{iM}^1) \tag{2}$$

In $w_{ij}^1, i = 1, 2, \dots, p, j = 1, 2, \dots, M$, showing the connection weights of neurons between the i neurons of competition layer and the j neurons of input layer. P is the number of neurons in the competition.

The output vector of the competition layer is

$$V = (v_1, v_2, \dots, v_p) \tag{3}$$

The connection weight matrix of neurons between competition layer and output layer is

$$W^2 = (w_1^2, w_2^2, \dots, w_N^2), w_k^2 = (w_{k1}^2, w_{k2}^2, \dots, w_{kp}^2) \tag{4}$$

In $w_{kr}^2, k = 1, 2, \dots, N, r = 1, 2, \dots, p$, showing the connection weights of neurons between the k neurons

of output layer and the r neurons of competition layer. N is the number of neurons in the output. Each neuron of the competition layer classifies input space by learning prototype vector. The competition layer through the study is named subclass, and the output layer through the study is named target class.

The study of the LVQ network combined with competitive learning and supervised learning has rules. Therefore, it needs a proper network behavior example for training network. Assume that there are the following training mode, that is

$$\{x_1, t_1\}, \{x_2, t_2\}, \dots, \{x_Q, t_Q\}$$

Among them, each target output vector $t_j (j = 1, 2, \dots, Q)$ has only a component to 1, all other components for 0. In order to carry on the learning process, usually each neuron of the competition layer is specified to each output neuron. It can be defined matrix W^2, W^2 column means subclasses, and line means classes. It's only a "1" in each column and this shows that the subclass belongs to the class of this line.

$$W_{kr}^2 = \begin{cases} 1 & \text{only } r \in k \\ 0 & \text{if } r \in k \end{cases} \tag{5}$$

W^2 once defined will no longer change, neural network learning is through the improved Kohonen rule. Change W^1 . In each iteration process, an input vector provided to the network, calculate each prototype vector and the distance between and through the competitive layer, and the distance to the nearest neuron gain competitive victory, the first element of the output value is set to 1, the type can be calculated to the output vector value, namely

$$Y = W^2 V \tag{6}$$

Obviously, each component in Y is only a nonzero elements. Assuming that the number is k^* , in this way, that is show that X is assigned to the class.

The following analysis of the classification results

First, if the classification is correct, namely, if, the hidden neurons of winning will move along the direction, the winning hidden layer neurons will move along with the direction of, according to the following cor-

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recting competition layer weight vector:

$$i^{*w^l}(t+1) = i^{*w^l}(t) + \eta(p(t+1) - i^{*w^l}(t)) \quad (7)$$

Second, if the classification is not correct, that is to say, $y_k = 1, t_k = 0$ and it represents the false hidden layer neurons win by competition, then it moves the neuron weights from X and modifies the weight vector of the competition layer as

$$i^{*w^l}(t+1) = i^{*w^l}(t) - \eta(p(t+1) - i^{*w^l}(t)) \quad (8)$$

Among it $\eta \in (0,1)$, is the proportional coefficient, and it reflects adjustment rate when modulating the weight matrix. $i^{*w^l}(t)$ represents the weight of the I^* th neuron in competition layer at the time of t . After such processing, each neuron moves to the vector who fall into the class of forming subclasses, and gets away from those vectors who fall into other classes.

LVQ algorithms process

LVQ algorithms of training process as shown in Figure 1. Seen from the Figure 1 first initialize network variables and parameters. Input vector or training samples.

Set

$$X(n) = [x_1(n), x_2(n), \dots, x_N(n)]^T \quad (9)$$

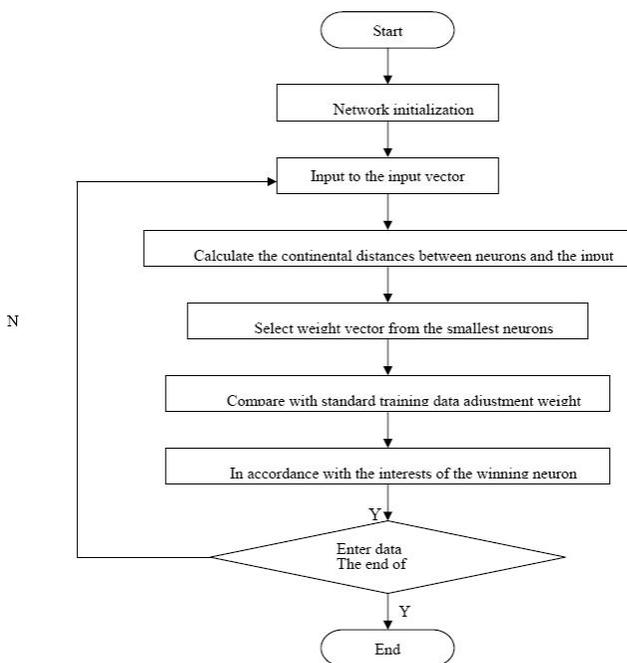


Figure 1 : LVQ training process diagram

for the input vector, or the Training samples.

Set

$$W_{i1}(n) = [w_{i1}(n), w_{i2}(n), \dots, w_{iN}(n)]^T \quad (10)$$

For the weight vector $i = 1, 2, \dots, M$. The select the learning rate function $\eta(n)$, set n for the number of iterations, N is the total number of iterations, The weight vector is $W_i(0)$, Learning rate is $\eta(0)$. And then, select the input vector x from the training set. By Euclidean distance the minimum standards for

$$|X - W_c| = \min |X - W_i|, \quad i = 1, 2, \dots, M \quad (11)$$

Finally, look for winning neuron, thus fulfilling the neurons in the competitive process. In determining the classification is correct, according to the learning rule in front of the adjustment of the weight vector of the winner neuron, adjust the learning rate $\eta(n)$, Determine the iteration number is more than N , if $n \leq N$ can be transferred to the input vector input, or the end of the iteration process.

ESTABLISHMENT OF FINANCIAL FAILURE PREDICTION MODEL

Determining the number of training samples without universal method, generally, if the sample is too short it may make the network expression too inadequate, resulting in insufficient ability of network extrapolation; but the sample is too many, it may lead to sample redundancy, which increases the network training burden, there may appear to contain information excess and make the overfitting phenomenon. In short, the selection process should pay attention to the representative and balanced sample, thus selecting the reasonable training samples. According to this principle, adopted here for real data of financial data to construct a bankruptcy prediction model from all of China's listing Corporation, the financial bankruptcy company selected refers to the continuous two years by stock market special treatment (ST) company. At the same time, based on the industry classification from other companies in the industry as normal, abnormal financial status, to most early birthday as the benchmark, selection of these companies in the financial statement data base has two years. We select 102 financial anomalies, 481 normal companies (the same company

in different years are considered different companies), set a total of 583 companies to build the sample. For reasons of space limitations, here to choose the 8 non ST company and 6 ST company's sample.

Training and test set partition

Taking all sample data into two parts, respectively is the training and test sets. Studies have shown that, in the process of building the classification model, if the number of training set in two kinds of sample data was equal, then the model was robust, so the training set consists of two samples of the same number (ST and non - ST companies are 5 samples). The test set ST and non ST samples were 1 and 3, for the test and evaluation accuracy of LVQ network model in the training set.

Selection of predictors

Prediction model of variable selection is to a large extent affects the model's forecasting accuracy. Reflect the enterprises financial position of as many as dozens of even hundreds of various financial indicators, covers the enterprise's solvency, profitability, capital management ability and growth ability and so on several aspects in the future.

Investigation on model selection of indicators used in the past has contributed significantly in research at home and abroad and are representative of the predictor variables, fully draw on the predecessors to outstanding achievements in research. By comparison, domestic and foreign experts and scholars in a large number of research results, some high frequency of financial indicators, and even financial index prediction model that is similar.

Altman through the combination of variables countless experiments to obtain Z famous score model; selected Shanghai, deep exchange 120 listing Corporation as the research object, the discriminant equation consists of 4 financial indexes.; Gao Peiye, Zhang Daokui selected state-owned enterprises in Shenzhen City as a sample, using multivariate decision technology concluded that final judgment model made of 5 financial indicators; Chen Xiao and Chen Zhihong also tested 1260 combinations of variables and selected 4, which has stronger ability to predict financial index.

Considering the coverage and the amount of calcu-

lation, the selection model of index, the spirit of fully reflect the financial situation of the enterprise, cost estimation, increase operational principle to reduce, and the research achievements of predecessors, choose the following 5 financial indexes as LVQ prediction feature vector model: the rate of return on net assets, liquidity ratio, equity ratio, total asset growth rate and working capital ratio. The sample data are shown in TABLE 1.

TABLE 1 : Sample data

Company Type	Net assets Rate of return	Flow Ratio	Equity capital Ratio	Total assets Growth rate	Operation Capital ratio
ST	0.25	0.31	0.27	0.19	0.12
ST	0.23	0.28	0.19	0.21	0.11
normal	0.75	0.61	0.75	0.50	0.50
ST	0.21	0.27	0.24	0.17	0.14
normal	0.78	0.60	0.68	0.50	0.52
normal	0.75	0.59	0.75	0.50	0.49
normal	0.81	0.60	0.71	0.50	0.50
ST	0.19	0.30	0.21	0.18	0.13
normal	0.81	0.60	0.72	0.50	0.57
ST	0.25	0.28	0.19	0.23	0.09
normal	0.73	0.55	0.67	0.50	0.61
ST	0.15	0.23	0.18	0.21	0.16
normal	0.72	0.61	0.73	0.50	0.62
normal	0.70	0.59	0.72	0.48	0.59

IMPLEMENTATION OF FINANCIAL FAILURE PREDICTION IN MATLAB

One advantage of pattern recognition is achieved by using LVQ neural network is the input vector does not need to be normalized, normalized treatment. In addition to the sample data of all have been located in the interval [0, 1], so for the data in TABLE 1, without the need for normalization processing, can be directly put into training and test.

(1) The target vector design create the input vector

Here are 5 of the use of ST's samples and 5 normal company samples as the training sample, ST, 1, with 2 representing normal.

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p=
 [0.25 0.23 0.75 0.21 0.78 0.75 0.81 0.19 0.81 0.25;
 0.31 0.28 0.61 0.27 0.60 0.59 0.60 0.30 0.60 0.28;
 0.27 0.19 0.75 0.24 0.68 0.75 0.71 0.21 0.72 0.19;
 0.19 0.21 0.50 0.17 0.50 0.50 0.50 0.18 0.50 0.23;
 0.12 0.11 0.50 0.14 0.52 0.49 0.50 0.13 0.57 0.09];
 This type of training samples for:
 tc=[1 1 2 1 2 2 2 1 2 1];

The category of vector TC function using ind2vec conversion for the network can use the target vector t: t=ind2vec(tc);

(2) creating a LVQ network

Neural network toolbox function used to create LVQ network is newlvq, create a LVQ network using the function.

```
net=newlvq(minmax(p),8,[0.5 0.5]);
```

Among them, 8 indicates the number of neurons of the network, [0.5 0.5] represents the input samples belong to the first class in the data accounted for 50%, belong to another category accounted for 50%, the learning rate and learning algorithms get default values, respectively is 0.01 and learnlv1. Because the number of neurons can affect the classification performance of network, so we need to choose to continue to experiment.

(3) Network training

The establishment of LVQ network, the need for effective training on the network. Using train neural network toolbox in the network training, training step by 1000, the training error using the default value of 0.net.trainParam.epochs=1000;

```
net=init(net);
```

```
net=train(net,p,t);
```

The training results:

```
TRAINR, Epoch 0/100
```

```
TRAINR, Epoch 2/100
```

```
TRAINR, Performance goal met.
```

Visible, the training function network is trainr, after training two times, the network error meets the requirements. The training results as shown in figure 2.

(4) Simulation

Simulation of the network is trained using the simulation function of SIM, check whether the network to the training samples of the input vectors were correctly

classified.

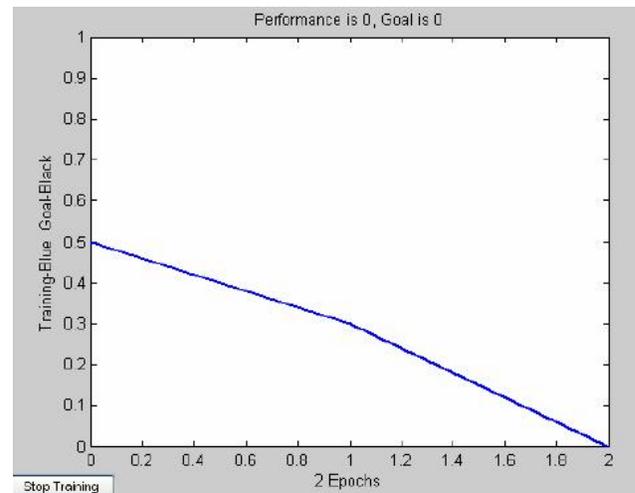


Figure 2 : The results of training (competitive layer unit 8)

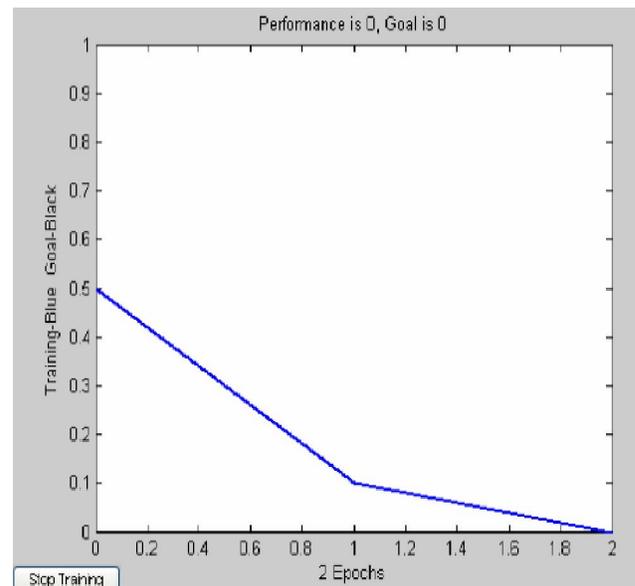


Figure 3 : The results of training (competitive layer unit 5)

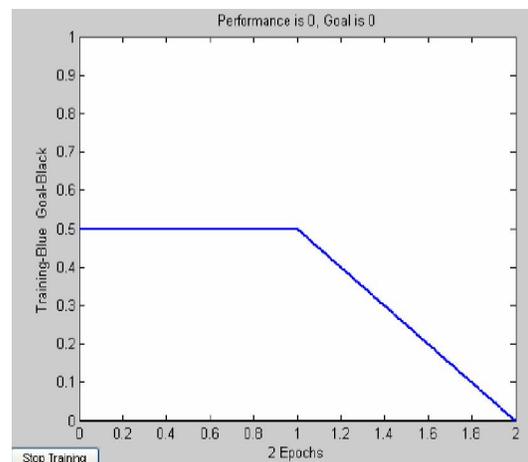


Figure 4 : The results of training (competitive layer unit 12)

```

y=sim (net,p);
yc=vec2ind (y)
The output results:
yc=1 1 2 1 2 2 2 1 2 1

```

yc=tc, visiblyly classification of network is correct. The simulation results show that, the network classification accuracy is very high, this shows, has established the LVQ neural network forecasting model based on financial failure.

(5) The test of the prediction model

The trained network needs to be tested to determine whether can be put into practical application. In order to verify the reliability of the model, the effective method for testing and inspection on it; in order to effectively and ensures the accuracy of the test result, the test data should be consistent with the training data. By using the cross validation method to test the model, which is based on the LVQ network test data (1 ST and 3 normal companies) classification

```

p_test=
[0.73 0.15 0.72 0.70;
0.55 0.23 0.61 0.59;
0.67 0.18 0.73 0.72;
0.50 0.21 0.50 0.48;
0.61 0.16 0.62 0.59];
tc_test=[2 1 2 2];
y_test=sim (net,p_test);
yc_test=vec2ind (y_test)
The output results;
yc_test=2 1 2 2

```

yc_test=tc_test, Visiblyly network conducted a successful classification of the input vec.

ERROR ANALYSIS

(1) Through gradual training, found that when the neurons in the hidden layer for 6~11 network after training 2 times, reached the target error, fast convergence, good effect, to meet the application requirements.

The training error curve consisting of different number of hidden units of LVQ network as shown in Figure 2, 3 and shown in Figure 4. By comparison, When the competition number of neurons is 8, faster network convergence, draw important conclusions that not the

number of hidden layer neurons the more, the better performance of the network. In the text, convergence rate has not significantly increased as the number of hidden layer neurons, and speed up the trend, such as when the number of hidden layer neurons increase from 8 to 12 o'clock, training process of network convergence has slowed.

(2) Financial failure prediction model based on BP network.

Based on BP network forecast can be achieved through a single hidden-layer BP network. Since the input vector of 5 financial index elements, so the number of neural network input layer is 5, according to the Kolmogorov theorem, the network middle layer neurons can take 11, the number of neurons in the output layer 1. Network middle layer neuron transfer function using S type tangent function Tansig, transfer function of output layer neurons using pure linear function of purelin, the network parameters and training parameters are shown in TABLE 2 and TABLE 3 shows.

TABLE 2 : Network parameters

The training function	Learning function	Performance function
trainlm	learnqdm	mse

TABLE 3 : Training parameters

Number of training	Training objectives	Learning rate
1000	0.0001	0.01

Middle layer is difficult to determine the number of neurons, which in turn is to a large extent affect the predictive performance of the network. Take 11 first, then observation network performance; after respectively 6 and 16, and to compare the forecasting performance of at this point, testing intermediate layer neurons number effect on network performance. When you minimize the prediction error of the network, network is the best value the number of neurons in the middle tier. Network prediction error curves as shown in figure 5.

(3) Comparison of LVQ network model and BP network model

Comparative figures 2 and 3 of the network training error curve, although both the model training times is 1000, learning rate is 0.01, but obviously, BP net-

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work model for training time is very long, training process convergence speed is relatively slow. Although $MSE=1.86335e-005/0.0001$, the mean square error of the output is very small, but relatively larger error model based on LVQ network, network performance is not 0, training error did not reach 0. The experiment results show that, comparing traditional LVQ neural network with BP network method, traditional LVQ neural network has high prediction accuracy, on input vectors to achieve a successful classification, has good prospects in this area.

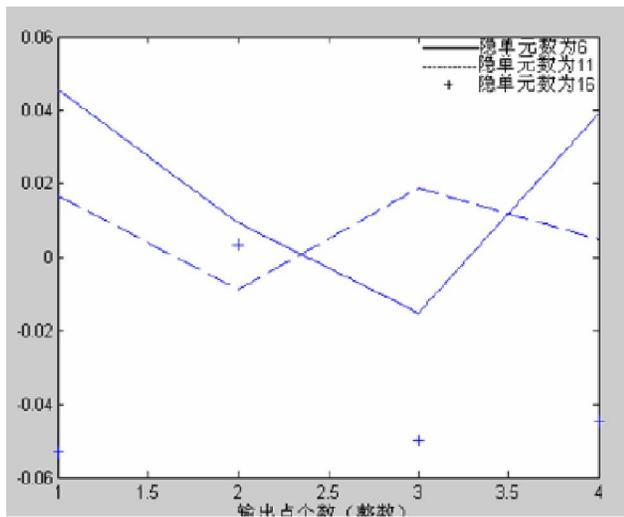


Figure 5 : Comparison of predicted error curve of BP network

CONCLUSION

In the fierce market competition, bankruptcy listed companies at home and abroad because of the financial crisis are common, one of the major reasons is the

enterprise failed to effectively monitor, prevent and avoid financial risks. Therefore, enterprises should establish effective mechanisms for financial forecasting to avoid the occurrence of financial failure. This paper established the index system of financial failure prediction of domestic listing Corporation, by using the method of LVQ neural network, the completion of the index system of the failure prediction model is established, and the LVQ network model is established for training and simulation results of the MATLAB neural network toolbox, is used to predict the listing Corporation's financial situation, and the selection of the sample obtained the prediction accuracy compared to the traditional BP neural network method is higher. Results showed that the methods are not only effective and practicable.

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