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Application of Innovations Feedback Neural Networks in the Prediction of Ups and Downs Value of Stock Market*

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***Abstract* - This paper presents how the idea of Kalman prediction can be used to the study of the prediction of neural networks and puts forward an Innovations Feedback Neural Networks(IFNN). IFNN adopts Back Propagation(BP) algorithm and is applied to the prediction of ups and downs value of the stock. The theoretical results and numerical experiment show that the predicted capability of IFNN is better than that of the normal feedforward networks. Finally, a relative completed stock prediction system is developed on Windows 2003/XP platform by OOP programming method and sql server2000 database. By practical operation in Resource Investment Consult Inc., it shows the system can improve prediction credibility of stock market effectively.**

Index Terms* - *innovations, feedback, neural networks, BP algorithm, stock prediction

I. INTRODUCTION

At present, artificial neural networks is applied in many fields as a complicated nonlinear dynamics system, although many problems and theories have to be researched further. Specially, after the BP algorithm is put forward, neural networks find applications more successfully in such diverse fields as modeling, time series analysis, pattern recognition, signal processing and control [1]. For the application of prediction in [2], the forecast system based on the neural networks is initially set up and applied example is put forward in the light of the problem of weather forecast; The prediction of the economic indices is realized based on neural networks according to the price nonlinear model in [3]; On the bases of demerit-analysis of route-selecting methods being used in switch, a new routing approach based on recurrent neural network prediction is presented [4]; Neural networks are used in the prediction of ups and downs of stock market, and research the pretreatment of the samples, the selection of the input units, the selection of the hide layer and the activation function etc. It gets a good result [5, 6].

Neural networks are utilized to forecast the ups and downs value of the stock here too. According to the idea of Kalman prediction, the dispersion is constructed between the true value and estimation value of ups and downs value of that very day's as innovations and is fed back to the inputs [7]. IFNN has been proposed and the prediction of ups and downs value of the stock been realized by BP algorithm. The result of the experiment shows that the predicted capability of the IFNN is better than that of the normal BP networks.

II. INNOVATIONS FEEDBACK NEURAL NETWORKS

By learning about the pairs of inputs and outputs and setting the number of hidden-layer nodes randomly, three-layer feedforward networks can approach a discretional nonlinear function which defined in a boundary close setting of R^n with arbitrary accuracy. So it's feasible to using three-layer feedforward networks to realize the prediction. The three-layer networks is composed of input layer, hidden layer and output layer which is shown in Fig.1. Their computation nodes are denoted by x_j , h_j and $\hat{y}_{km}$ respectively. Where $\hat{y}_{km}$ refers to the predictive estimation value at the k th output of neuron at the m th moment. The symbol w_{ji} denotes the synaptic weight connecting the hidden layer of neuron j to the input of neuron i , the symbol w_{kj} denotes the synaptic weight connecting the output of neuron k to the hidden layer of neuron j .

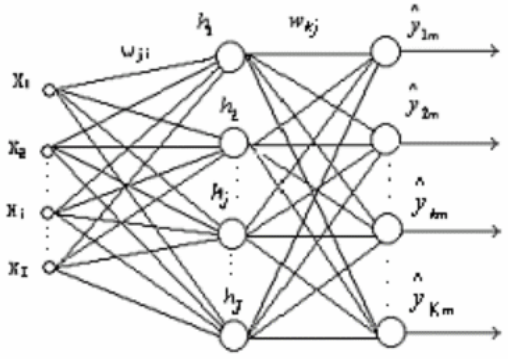

Fig.1 Multiplayer feedforward networks (MLP)

In control theory field, Kalman prediction theory can realize the prediction of the state. On condition that having known the observation vectors $z(0)$, $z(1)$,…, $z(m-1)$, it's

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feasible to get the estimation $\hat{x}_{(m+1/m-1)}$ at the $(m+1)$ th moment by state equation. After the observation vector $z(m)$ is gained, the dispersion between $z(m)$ and its estimation $\hat{z}_{(m/m-1)}$ can be used as the useful innovations to update the estimation $\hat{x}_{(m+1/m-1)}$, and then to obtain the one step estimation $\hat{x}_{(m+1/m)}$ of the state vector $x(m+1)$. It's significant that putting forward the concept of "innovations" and the idea of innovations updating in prediction field. This method is applied in the neural networks prediction. Add structure of feedback to the neural networks which is shown in Fig.2. Where z^{-1} denotes a lag of a moment and y_{km} denotes the true value at the k th output of neuron at the m th moment. Feed the dispersion between the y_{km} and $\hat{y}_{km}$ back to the input layer as the innovations which reflects the accurate degree of prediction result at the m th moment, to update the result of the prediction at the $(m+1)$ th moment. The networks use the method of gradient descent and error back propagation algorithm to update the connecting weight w_{ji}, w_{kj}. This network is named as IFNN which is illustrated in Fig.2.

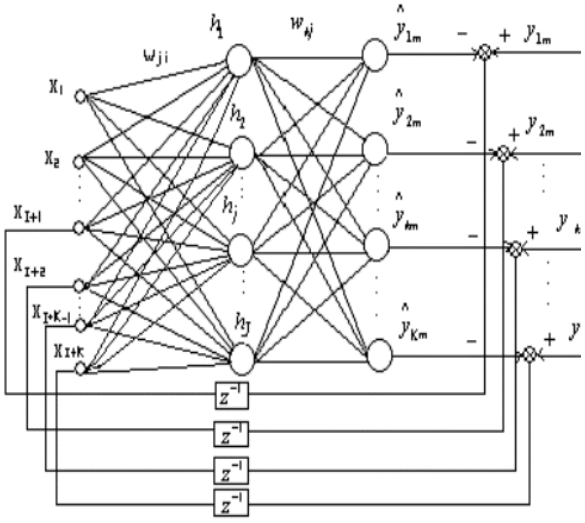

Fig.2 The model of IFNN

III. IFNN Application In The Prediction Of Ups And Downs Value Of Stock

Ref. [3] realizes the prediction of ups and downs of the stock market by using three-layer feedforward networks. Three-layer IFNN is used to predict the ups and downs value of the stock. The structure of the networks used in this experiment is schematically presented in Fig.3. The activation functions of hidden layer and output layer are both sigmoid function, viz. $f(x)=\frac{1}{1+e^{-x}}\in(0,1)$. Suppose $p_{\max}$, $p_{\min}$ are the maximum and minimum of the ups and downs value in N days, p and $\hat{p}$ are the true value and estimation value of ups and downs value respectively. Map p and $\hat{p}$ to the section [0.001,0.999], by function:

$$y \ or \ \hat{y}=\frac{(p \ or \ \hat{p})-p_{\min}}{p_{\max}-p_{\min}}\times(0.999-0.001)+0.001 \qquad (1)$$

Then get the true value y and estimation value $\hat{y}$ of relative ups and downs value respectively.

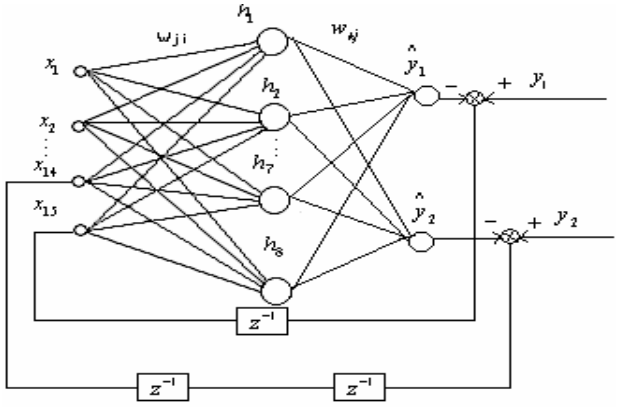

Fig.3 The structure of the network applied in the prediction of ups and downs value of stock

The three-layer IFNN is composed of 15 input-layer nodes, 8 hidden-layer nodes and 2 output-layer nodes. The implication of the input-layer nodes is listed in table 1. The selection of the first 13 input-layer nodes is to reflect the characteristic of the stock market trade and each day of the data indices are considered to be connected and affected mutually. Because the inside characteristics of the samples are crossed. In doing so, not only the influence of the short-term factor is considered, but also the balance effect of the long-term factor is paid attention to as in [6]. Because there is much difference in the input data of samples, in order to balance the control effect of every input, it's necessary to standardize x_1 □ x_{13}, which is shown in table 2. The rest two input-layer nodes are the innovation feedback input nodes. x_{14} is the dispersion between today's true value of relative ups and downs value and estimation value of relative ups and downs value which is the prediction of the day before yesterday for today, x_{15} is the dispersion between today's true value of relative ups and downs value and estimation value of relative ups and downs value which is the prediction of yesterday for today. The output $\hat{y}_1$ means estimation value of relative ups and downs value which is the prediction of today for tomorrow, and the output $\hat{y}_2$ means estimation value of

relative ups and downs value which is the prediction of today for the day after tomorrow. y_1 means the true value of relative ups and downs of today for tomorrow, $y_1 - \hat{y}_1$ is fed back to x_{15} through one day's delay.

TABLE I
INPUT LAYER NODES

Input nodes	Illustration	Input nodes	Illustration	Input nodes	Illustration
x_1	Today's maximal price	x_2	Today's minimal price	x_3	Price of today's open quotation
x_4	Price of today's closing quotation	x_5	Today's trading volume	x_6	Yesterday's trading volume
x_7	Trading volume of the day before yesterday	x_8	Average trading volume in 30 days	x_9	Ups and downs value of today
x_{10}	Ups and downs value of yester day	x_{11}	Ups and downs value of the day before yesterday	x_{12}	Average ups and downs value in 10 days
x_{13}	Average ups and downs value in 30 days				
x_{14}	today's true value of relative ups and downs value - estimation value of relative ups and downs value of the day before yesterday for today				
x_{15}	today's true value of relative ups and downs value - estimation value of relative ups and downs value of yesterday for today				

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TABLE 2
THE STANDARDIZE OF THE INPUTS

$x_1 \sim x_4$	$x_5 \sim x_9$	$x_{10} \sim x_{13}$
(2.0～3.0)	(0.5～5)	(-3.0～3.0)

Meanwhile y_2 means the true value of relative ups and downs of today for the day after tomorrow, $y_2 - \hat{y}_2$ is fed back to x_{14} through two day's delay. z^{-1} refers to one day's delay. There's no prediction of yesterday and the day before yesterday for the first day of the samples, so the inputs x_{14}, x_{15} of the first day are both 0. Meanwhile, there is no prediction of the day before yesterday for the second day, so the input x_{14} of the second day is 0.

The initial value of the networks connecting weights w_{ji}, w_{kj} are assigned in (-0.05,0.05) randomly. Learning-step parameter η is an important parameter, which decides the convergent rate on a certain degree. However, by assigning a small value to η, the convergent rate will progress slowly; by making η too large, the result changes widely in the synaptic weights assume such a form that the network may become unstable. According to [6], it chooses η=0.28, α =0.001. Update the value of η in every iterations to improve the adaptive capability and speed up the convergent rate by using function: $\eta^{new} = \eta^{old}(1-\alpha)$. In order to get more information of prediction from the two additional inputs, convergent rate parameter η is assigned as 0.6 when updating the weight connecting x_{14} to hidden layer and the weight connecting x_{15} to hidden layer. For the samples of the learning, the function of computing error is as follows:

$$E_k = \frac{1}{2}\sum_{m=1}^{M}(y_{1m} - \hat{y}_{1m})^2 \quad (k=1,2), \tag{2}$$

Where M is the number of the learning samples, the maximal number of iterations is 4000.

After mapping the ups and downs value to the section [0.001,0.999], Equation (1) shows that the relative ups and downs value $0.998\frac{-p_{\min}}{p_{\max}-p_{\min}}+0.001$ is neither falling nor rising. Thus the value in section $(0.998\frac{-p_{\min}}{p_{\max}-p_{\min}}+0.001, 0.999]$ is rising, and the value in section $[0.001, 0.998\frac{-p_{\min}}{p_{\max}-p_{\min}}+0.001)$ is falling. If $\hat{y}_1$ and y_1 fall in the same section, it's reasonable to believe that the prediction is correct. Otherwise, it's necessary to compare the two values. If their dispersion is in a small area, the prediction is considered correct too. In this paper, $|y_1 - \hat{y}_1| \le 0.1$ is adopted as the small area.

IV. EXPERIMENTAL AND DEVELOPMENT

The stock is chosen which code is 600222 (HENAN JOYLINE & JOYSUN HARMACEUTICAL STOCK CO.,LT). The data indices of 70 successive bargain days (from May 15,2000 to August 21,2000) is adopted as the sample of learning, the data indices of 30 successive bargain days (from August 22,2000 to October 9,2000) is selected as the sample of prediction. Because a lot of uncertain interference factors exist in the stock market, it assumes that the sample chosen is the sample data under the normal operation situation. This can find the universal law of the stock exchange. Therefore, in order to predict the ups and downs value, three-layer feedforward networks and IFNN are used to learn and predict with the same samples of learning

and prediction respectively. BP algorithm is adopted as the learning algorithm.

The structure of the three-layer feedforward networks is as follows: 13 input nodes which is the same as $x_1 \sim x_{13}$ shown in table 1, one output node which refers to the relative ups and downs value of today for tomorrow, 8 hidden nodes. According to the above method of judging the prediction credibility, for the feedforward neural networks the precision of prediction is 73%; While for IFNN, the precision of prediction is 76%. It shows that IFNN has more advantage than that of normal feedforwrd network. Fig.4 summarized the two output's learning curves of IFNN.

Based on IFNN, the prediction system of ups and downs value of stock market is developed under WWW environment by ASP.net and sql server2000. The system includes four function modules as follows: the previous processor program, data upload & download program, the automatic drawing & dynamical showing program of everyday K curves, average curves and prediction curves, the query of stock code and trend prediction program, which provide intuitionistic reference for stock investors. The analysis interface of the system is shown in Fig.5.

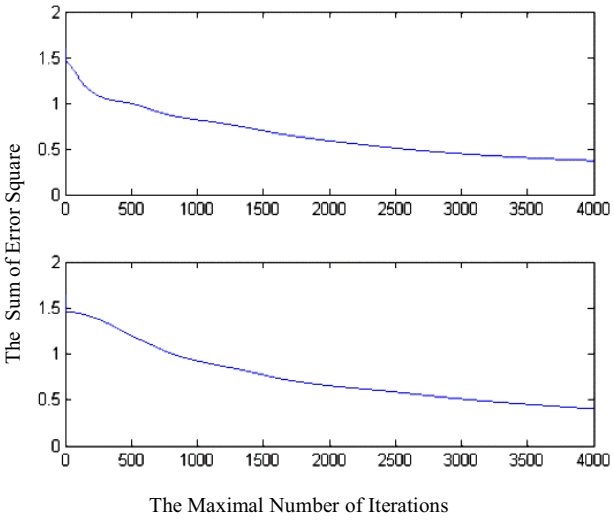

Fig.4 The two output's learning curves of IFNN

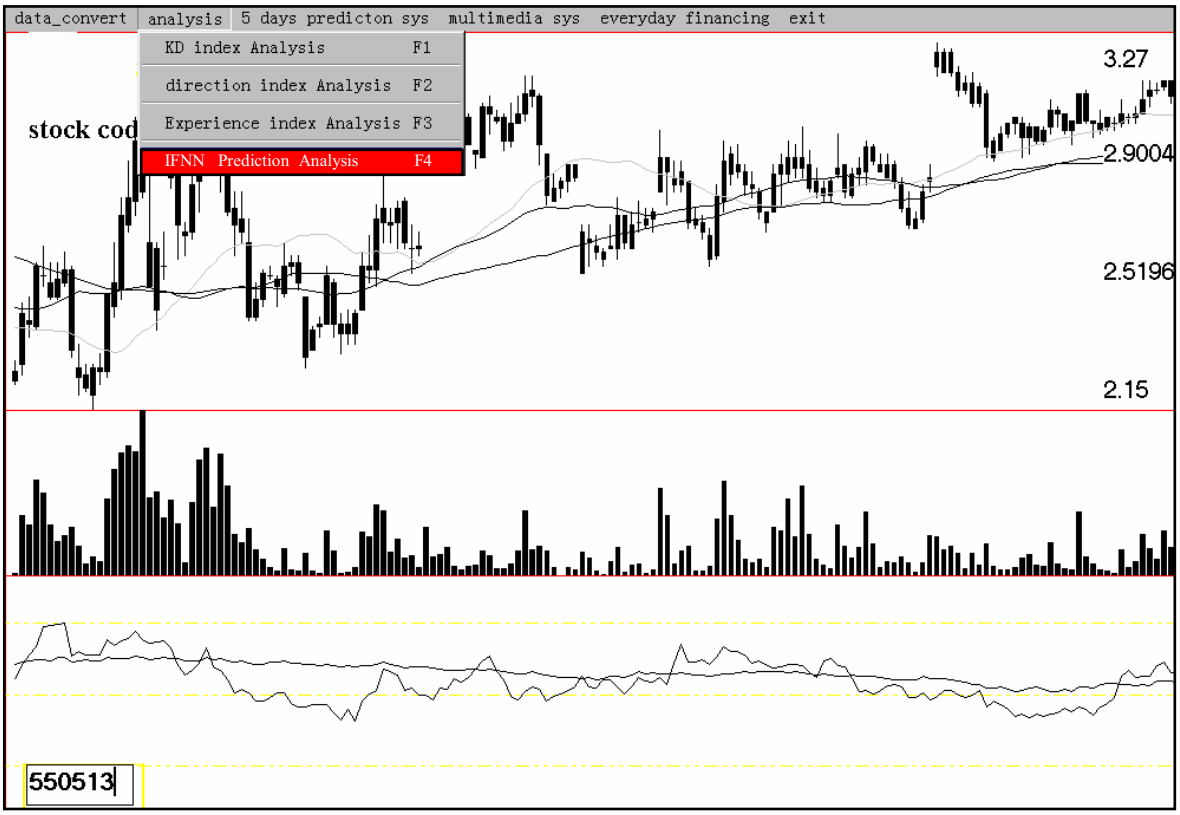

Fig.5 The stock analysis prediction interface of the system under WWW environment

V CONCLUSION

The paper presents a structure of IFNN which contains the information (innovations) of updating the prediction, aiming at increasing the precision of the prediction and applies the networks in the prediction of ups and downs value of stock. Through experiment, IFNN can get better result by using in the prediction of ups and downs value of stock, it has better capability of generalization and prediction. By using OOP technology and IFFN theory, a stock analysis system is developed and runs smoothly in the New Resource Consult Inc, which proves that the IFFN is valid to stock prediction.

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