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An Intelligent Demand Forecasting Model with Back Propagation Neural Network for Fish Product

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Abstract: Taiwan joined the WTO since 2000, five years later the agricultural and fishing products can be freely imported. Faced with such a shock, how to reduce the production cost of agricultural or fishery products would be an important issue. In the low-profit era, production costs often affect the operation of enterprises in an important factor. In particular, the production cost of agricultural and fishing products, particularly significant. The operating personnel need spend much capital on the stock of goods in the traditional fish industry. However, the price of fish product is changing daily based on the supply and demand in the market. The operating personnel can buy at low price and achieve the objective of short-term stock according to the short-term demand if the information technology can be used to assist them to forecast the demand in the future. It can not only increase the profit, but also enable the backward customer get the fresh fish product with low price and assist them to reduce the material cost. Therefore, this study has the back-propagation neural network predict. Enterprises using case history of each fishery products, orders goods sales records forecast future purchases. Establishing the future order prediction model in fisheries products, in order to achieve the purpose of reducing production costs and enhance their competitiveness.

Key words: Back propagation neural network algorithm, fishery demand, forecasting system

INTRODUCTION

The transportation and sale of fish product means the economic activity that the fish product is sent to the consumer or subsequent manufacturer through the working procedure from production to collection, classification, transportation, storage, processing, sale, financing and market information collection. However, the price is an important factor with great influence on the operating other than the product freshness in the fish product transportation and sale industry. The price of fish product will reflect in the fish product auction market based on the market demand and the supply from feeding and fishing at any moment. Therefore it will be much advantageous for the operating personnel if the short-term demand of customer in the future can be forecasted (Mcgarvey, 2003).

This research achieves the object to forecast the fish product demand with back propagation neural network algorithm. We also expect to combine the theory and practice with the cooperation with the fishing personnel in the future (De and Antoni, 2004; Smith and Mentzer, 2009).

This study focuses on fishing supply industry, procurement orders for the current model and put forward feasible and effective ways of improvement. Using historical data of orders with back-propagation neural network algorithm creates a method to predict the future purchases of fishing products. This not only can work more accurate, rapid, and can significantly reduce costs and increase profits.

Neural network: The neural network is called NN for short. It mainly simulates the behavior of brain and neural network to process data, and has the inference, map, induction, judgment, self-learning, experience accumulation and error acceptance capacity for the input information. It can be used extensively in all fields such as data analysis, fault diagnosis, voice distinguishing, letterform distinguishing, resolution consultation, process monitoring, video diagnosis, specialist system, automatic control and optimization resolution (Lin, 2000; Tang, 2001; Wang and Xiao, 2002). This study will apply the neural network to the forecasting of fish product demand.

The neural network is an inspiration from the biology; Its patterns are just like the neural organizations of biology and connected with nerve cell to imitate the information process capacity of biologic neural network. The exact definition is as follows: the neural network is a calculation system including software and hardware; it

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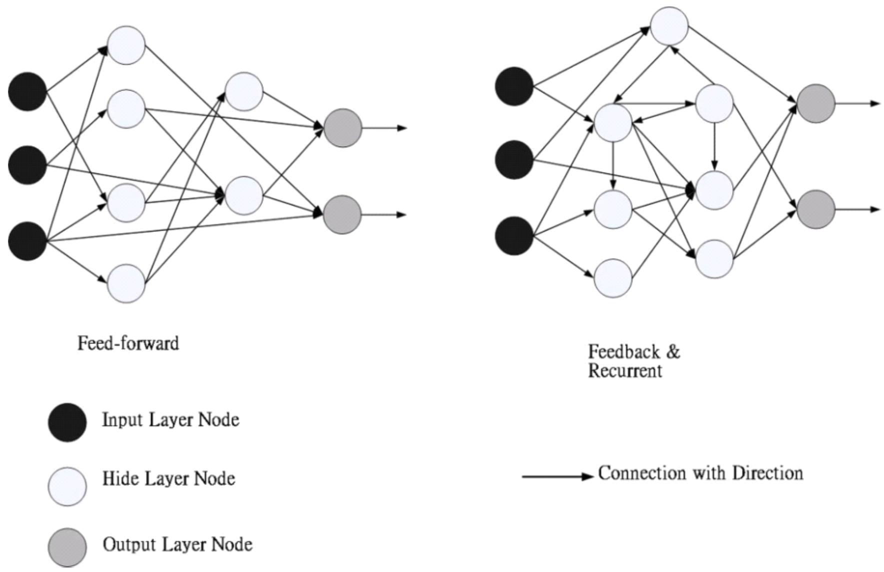

Fig. 1: Sketch of neural network structure (Wong *et al*., 1997)

uses quantities of sample linked artificial nerve cells to imitate the capacity of biologic neural network (Ye, 2000). The artificial nerve cell is the simple imitation of biologic nerve cell; it gets the information from the external environment or other artificial nerve cells and makes simple calculation, then outputs the result to the external environment or other artificial nerve cells.

Since the neural network is the parallel distributed process calculator mode with the feature of high parallelism, distributed associative memory, error acceptance, adaptive and self-learning from environment, it can be used extensively in the fields of graph distinguishing, voice distinguishing and synthesizing, code process, video compression process, specialist system establishment and decision-making analysis. It has also been used in the financial filed widely in recent years (Fan, 2004).

After the development of neural network stagnated over 10 years in 1970s, the research of Hopfied in 1982 is the important breakthroughs in the development history of neural network, which make the relevant research on neural network, attract the recognition of the entire science society. The paper introducing the principle of back propagation written by McClell and Rumelhartthat in 1986 is the neural network literature cited most till now (Marsland, 2009; Issanchou and Gauchi, 2008). Their contribution to neural network makes the neural network revive and develop vigorously today.

The study will introduce the single nerve cell in the neural network at first, then present the structure of neural network, and the neural network structure can usually be divided into feed-forward and feedback and recurrent. At the same time, there are 4 key learning modes for the neural network: supervised, unsupervised, associated, and optimization application (Huang *et al*., 2007), and we will make a brief review here.

Neural network structure: The neural network structure can be divided into feed-forward and feedback and recurrent (Fig. 1). The most difference between these two structures lies in that there is no circulation in the Figure representing the feed-forward network, while the feedback and recurrent network can result into feedback via recurrent to adjust the weight value and threshold value. In the practical application, about 90% neural networks adopt the feed-forward.

The different neural network structures will lead to different behaviors of network. Generally, the feed-forward neural network is static network, one set of input will just result into one set of output, and this set of output will not change the network; while the feedback and recurrent neural network will feedback to the network and change the weight value and threshold valued of network via this set of output, so that a new network will emerge.

Neural network learning mode: The neural network learning mode generally can be divided into 4 catalogues:

Supervised learning network: The supervised learning is a learning mode to popularize the feature, i.e. teaching the student to distinguish the article and tell him the feature and name of article, and then the student can still distinguish when he sees the article that is not completely similar to the original one. The supervised learning network is also named the excavation of classification rule; the training example including the input value and output value must be obtained from the field of the problem. This network will be trained at first, then the weight value will be adjusted according to the difference between the actual output value and expected output value; it means that the network will learn the map rule between these two values and then apply it to the new case (Huang *et al*., 2007). The object of supervised learning is to reduce the difference between the actual output value and expected output value, and it can be used in forecasting and classification, for example:

- Back propagation network
- Reverse propagation network
- Perception network
- Probability Neural Network
- Learning Vector Quantization Network

Unsupervised learning network: The unsupervised learning is also named data conclusion or the excavation of feature rule. The unsupervised learning network just inputs the data, and no data output is expected so that there is not the requirement of minimum error. The training mode is to learn the classification rule between samples based on the input data and adjust the weight matrix of network itself without supervision so that the network can sort to be a consistent or similar output vector and be used in the distinguishing of samples (Ye, 2000) for example:

- Adaptive resonance theory network
- Self-organizing map network

Associated learning network: To learn the rule of internal association memory from the examples and apply it to new examples is usually used in the data reconnaissance and noise filtering (Ye, 2000), for example:

- Bi-direction associative memory network
- Hopfield neural network

Optimization application network: The variable will be designed to achieve the optimal design object in the condition to satisfy the restriction terms of design according to different problems (Huang *et al*., 2007), for example:

- Annealed neural network
- Hopfield-tank neural network

Back propagation neural network: The back propagation neural network is one of the most representational modes used extensively in all neural network learning modes at current. Werbos and Parker have brought forward the basic concept in 1974 and 1982 respectively, but it is till 1985 that Rumelhart, Hinton and Williams of Stanford University brought forward the propagation learning rule or generalized delta learning rule that this theory and algorithm has been defined definitely (Wang and Xiao, 2002; Huang *et al*., 2007).

The basic principle of back propagation neural network is to make use of the gradient descent method to minimize the error function and thus derive the delta rule, and its idea is to reduce the difference between the actual output and expected output with a successive correctional value. From the viewpoint of mathematics, the correction of synapse value is direct proportion to the 1st differential of error value, which can testify it will converge to a stable state in the process of network learning, equivalent to the minimum value of a curve on the plane (Min *et al*., 2009).

The processing process of back propagation network includes forward pass and backward pass, and the error can be reduced and the expected learning fruit can be achieved through these two stages. The forward pass begins from the input layer, transfers the original data to the vector and input into the network, and they will be calculated by each layer of nerve cell till the last layer of network. The backward pass is to pass from the output layer to the input layer and consisted of the error calculation and weight value update. Its method is to compare the difference between the object output and actual calculated values at first, then adjust the synapse value of network to reduce the error to the minimum (Wang and Huang, 2008; Huang *et al*., 2009).

There are 2 works for each nerve cell:

- Connection

$$\mu_i(k+1) = \sum_{j=1}^{N} W_{ij}(k)a_j(k) + \theta(k) \tag{1}$$

- Activation

$$a_i(k+1) = f\left(\mu_i(k+1), \mu_i(k), a_i(k)\right) \tag{2}$$

The nerve cell will implement the connection and activation repeatedly to update the activation value a_i on the nerve cell. It will be passed to the other nerve cells when a new activation value emerges. Eq. (1) and (2) is named system dynamical equations together, in which index k indicates the update times, u_i represents the output value of nerve cell i, w_{ij} denotes the weight value between nerve cell i and j, θ_i is the internal threshold value of nerve cell i, N is the number of nerve cells connected with nerve cell i, f(●) is the transition function, which is from the simplification of biologic effect in the nerve cells.

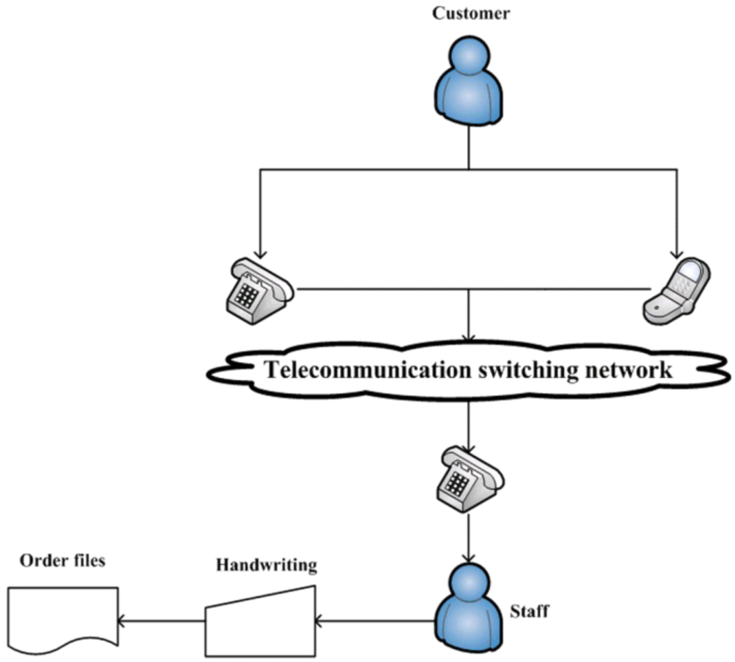

Fig. 2: Flowchart of the traditional order

MATERIALS AND METHODS

This study was conducted with Ruixiang fish product wholesaler in 2009. The main method of the present order with the customer is by telephone (Fig. 2). The main reason for fishing stock price volatility is that fish market auction. The fish market auction made the price uncertainty, but also represents the price of goods change at any time.

In fact, changing the traditional order processes must take into account the information level of employees. Most of the employees of the company would not use the Internet. The company's customers are mostly fishmongers, a small wholesale business, is a traditional part of the industry. In the face of information technology is a very slow pace. Therefore, how the system can do to facilitate ease of use will also be one of the key design considerations.

Understanding with the companies, it was found to reduce the cost of procurement only rely on traditional order information systems and can not fully achieve the desired purpose. The reason for this problem is fisheries goods procurement will be with the daily price of the auction market conditions vary. The seasons and other factors would affect fishing price, related research in the past can be predicted. However, suppliers are unable to predict the number of downstream demand purchases. If the amount of order can be predicted, then suppliers can purchase fishing goods when the price is relatively low. Therefore, in-depth understanding and for the conduct and business related discussions, this study suggests that only building a fisheries goods ordering information system does not meet the needs of business, nor can the maximum for a competitive advantage. Therefore, this study proposes a fishery goods orders and demand estimation information systems. In addition to the information system for the order, but more important is the use of back-propagation neural network algorithm to build the estimated demand system. The order information would pass to back-propagation neural network to estimate the future demand. System architecture of this study is shown in Fig. 3.

According to the relevant literatures, the supervised learning network must get the training sample in the field of problem, including the input value and output value. This network will be trained at first, then the weight value will be adjusted according to the difference between the actual output value and expected output value; it means that the network will learn the map rule between these two values and then apply it to the new case. The object of supervised learning is to reduce the difference between the actual output value and expected output value, and it can be used in forecasting and classification. Therefore the famous back propagation neural network algorithm in the supervised learning methods can be used to forecast the fish product demand in the future, and the application method will be detailed as follows.

Demand forecasting parameter conversion: We find that the production and demand of fish product are

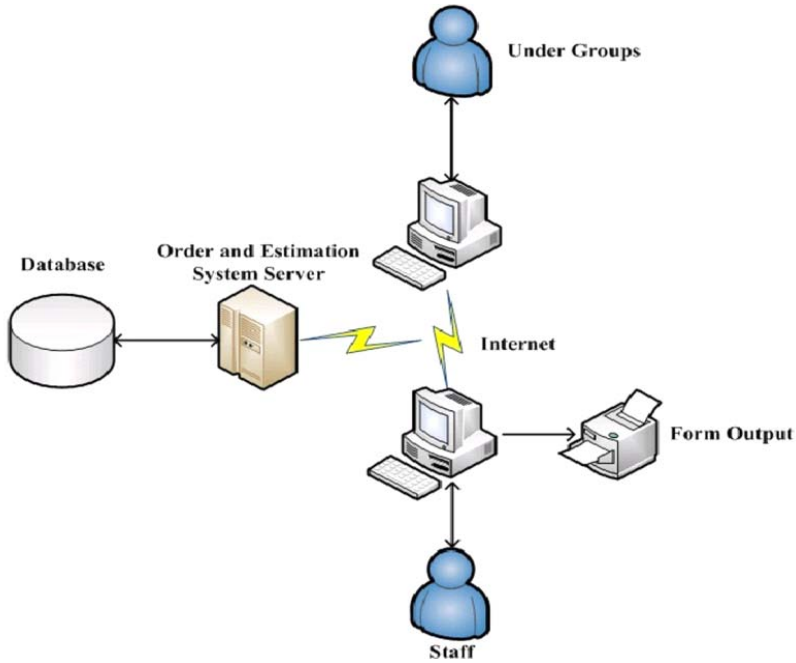

Fig. 3: Fishery goods orders and demand estimation information system architecture diagram

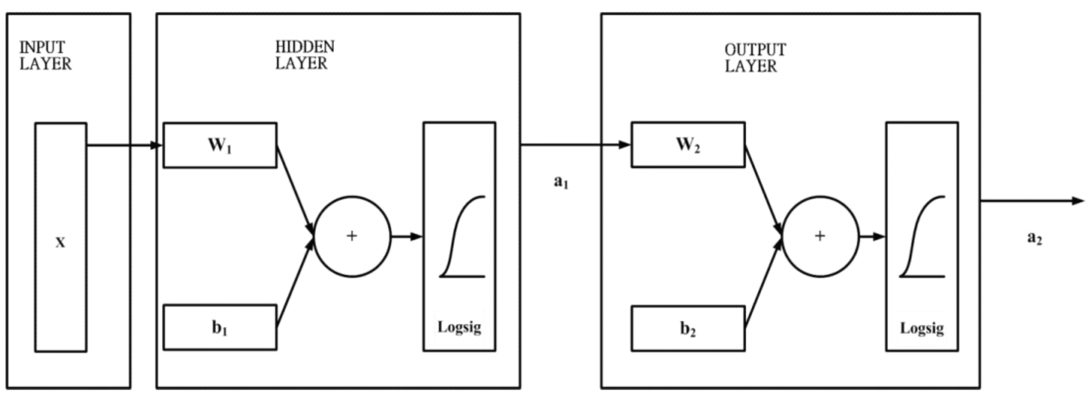

Fig. 4: Back propagation neural network order demand forecasting structure

different in different seasons based on the investigation and analysis on the fish product market. Firstly, we convert the fish product order of each cycle (solar term, week or month) into the input matrix (X_1 ,…, X_n) according to the amount and gross amount of different kinds of fish product, and the output matrix will be obtained from the proper conversion of the amount of different kinds of fish product in the order of next circle. For the conversion method, refer to Table 1.

Demand forecasting algorithm: The back propagation neural network order demand forecasting module will be built according to the back propagation neural network algorithm after the proper input matrix and output matrix

Table 1: Comparison of Input matrix conversion

Input parameter	Meaning
X_1	Gross Weight of Demand (Kg)
X_2	Demand Ratio of Fish Product A
X_3	Demand Ratio of Fish Product B
X_4	Demand Ratio of Fish Product C
X_5	Demand Ratio of Fish Product N

is obtained, and the module structure will adopt a hide layer, Fig. 4, which can also be denoted with Eq. (1):

In which X in the input layer indicates the input matrix, and this matrix is the parameter matrix conversed from the order of each cycle according to the amount of different kind of fish product. a_1 is the output matrix of hide layer, a_2 is the output matrix of output layer, which represent the order demand matrix to be forecasted:

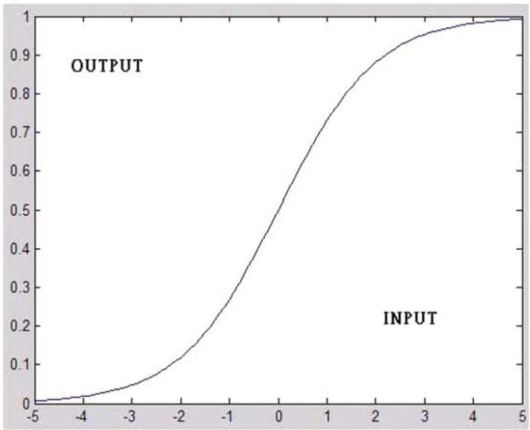

Fig. 5: Conversion function input and output relationship

$$a_2 = f\left(W_2 \bullet f\left(W_1 \bullet X - b_1\right) - b_2\right) \tag{1}$$

In which f() indicates the conversion function, the W_1, b_1, W_2, b_2 in the hide layer and output layer will be obtained from the calculation of back propagation neural network training algorithm, which will be detailed below. According to the relevant literature, the conversion function expected to be used in this research is Logsig, and its output and input relationship is as showed in Fig. 5.

The learning and training process of weight matrix of neural network hide layer and threshold vector, weight matrix of neural network output layer and threshold vector is detailed as follows:

- Input a set of training sample vector X and expectation object vector T.
- Calculate the actual output vector of network.
  - Calculate the output vector of hide layer.

$$n = \sum W_1 . X - b_1 \tag{3}$$

  - $a_1 = f(n) = \log sig(n) = \dfrac{1}{1+e^{-n}}$ (4)
  - Calculate the actual output vector a_2 .

$$m = \sum W_2 . a_1 - b_2 \tag{5}$$

$$a_2 = f(m) = \log sig(m) = \frac{1}{1+e^{-m}} \tag{6}$$

- Calculate the difference E between the output vector and object vector T.

$$E = T - a_2 \tag{7}$$

- Update the weight value W and threshold value b.
  - Update the weight value W_2 and threshold value of output layer.

$$W_2(new) = W_2 + \Delta W_2 \tag{8}$$

  - $b_2(new) = b_2 + \Delta b_2$ (9)
  - Update the weight value and threshold value of hide layer.

$$W_1(new) = W_1 + \Delta W_1 \tag{9}$$

  - $b_1(new) = b_1 + \Delta b_1 b_1(new) = b_1 + \Delta b_1$ (10)

- In which the calculation method of weight correction valueand threshold correction value is as follows:

$$\Delta W_2 = \eta \delta_2 a_1^T \tag{12}$$

$$\Delta b_2 = -\eta \delta_2 \tag{13}$$

$$\Delta W_1 = \eta \delta_1 X^T \tag{14}$$

$$\Delta b_1 = -\eta \delta_1 \tag{15}$$

η in the Eq. (11) to (14) represents the learning efficiency, which is set by the user, and the calculation method of $\delta_{1,}\delta_2$ is as follows:

$$\delta_2 = -2F_2(m)(T - a_2) \tag{16}$$

$$F_2(m) = \begin{bmatrix} f2(m_1) & 0 & 0 \\ 0 & f_2(m_2) & 0 \\ 0 & 0 & f2(m_i) \end{bmatrix} \tag{17}$$

$$f_1(m_i) = \frac{d}{dn}\left[\frac{1}{1+e^{-m}}\right] = (1-a_2)(a_2) \tag{I8}$$

$$\delta_1 = F_1(n)(W_1)^T \delta_2 \tag{19}$$

$$F_1(n) = \begin{bmatrix} f_1(n_1) & 0 & 0 \\ 0 & f_1(n_2) & 0 \\ 0 & 0 & f_1(n_i) \end{bmatrix} \tag{20}$$

$$f_1(n_i) = \frac{d}{dn}\left[\frac{1}{1+e^{-n_i}}\right] = (1-a_1)(a_1) \tag{21}$$

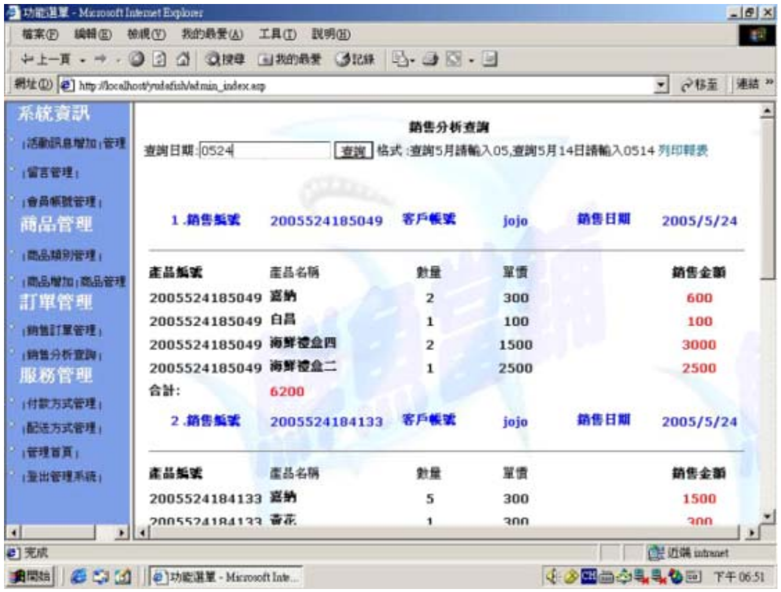

Fig. 6: The time based sales analysis

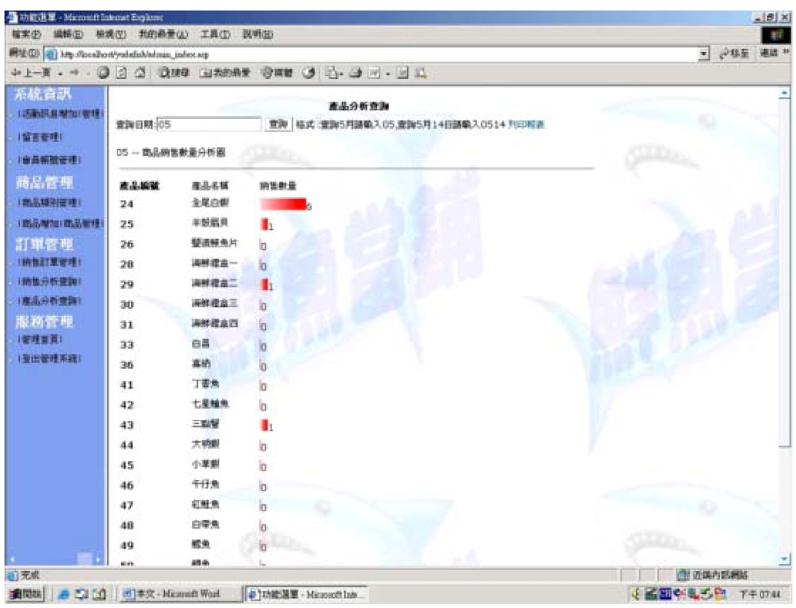

Fig. 7: Types of fish based sales analysis

Table 2: Estimation result

Training					Testing		
Sample size	Success training	Success rate	Mean Square Error	Learning times	Sample size	Success Testing	Success rate
30	60	100%	10^{-15}~10^{-16}	37481	30	15	50%
45	72	100%	10^{-15}~10^{-16}	4089	30	19	63%
60	90	100%	10^{-3}~10^{-4}	100000	30	24	80%

Repeat the above steps till the error E have not obvious changed, i.e., the convergence is achieved and the learning is finished. The deposited weight value W_1, W_2 and threshold value b_1, b_2 will represent the order feature concluded from the former orders after the learning is finished. Substitute the weight value matrix and the

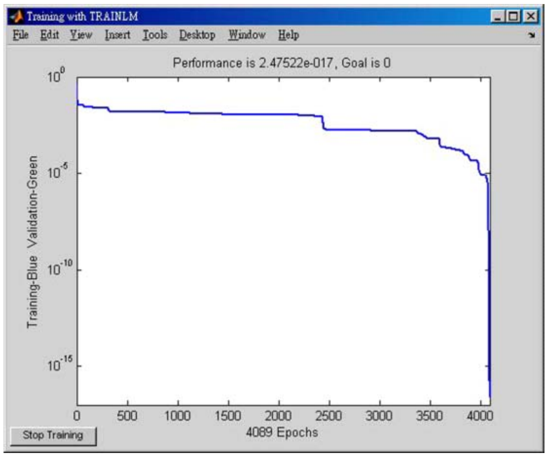

Fig. 8: Convergence process of sample size 30

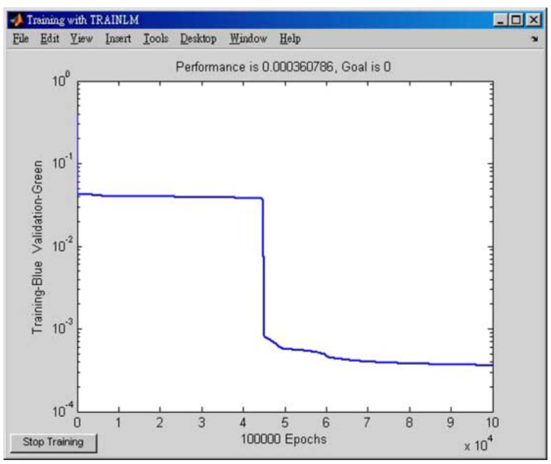

Fig. 9: Convergence process of sample size 45

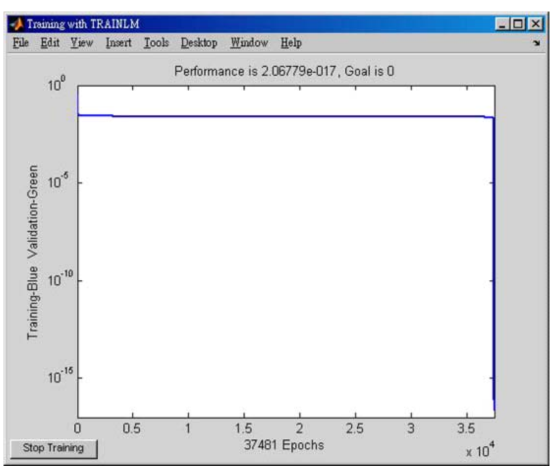

Fig. 10: Convergence process of sample size 60

threshold value matrix into the Eq. (1) for the subsequent back propagation neural network order demand forecasting module to calculate the order demand forecasting.

RESULTS AND DISCUSSION

This study proposes a more efficient electronic ordering method. Verification and approval by the business supplier A, this system model and methods can indeed help companies improve their market competitiveness and profit margins. The system sales analysis is showed as Fig. 6 and 7. The simulation of this paper is based on a quarter order amount in 2009 for the traditional fishery product supplier A.

The test data that is provided by the supplier A can be classified into the training samples and the test samples, and the corresponding sample sizes are 30, 30, 45, 30, 60 and 30, respectively. The simulations are performed based on the algorithm of Back Propagation Neural Network, and the simulation results are summarized as Table 2.

Convergence process of Mean square error in these simulations is showed as Fig. 8-10.

CONCLUSION

According to simulation results, shown as Table 2, it is applicable for Back Propagation Neural Network on the estimated system of fishery product demand. However, because it is difficult to collect historical data from traditional fishery industry, more test data will be discovered for performing training and improving the success rate of estimation that can be used to modify the proposed algorithm for achieving higher efficiency in the future.

This research makes use of the back propagation neural network algorithm to attempt to forecast the fish product demand, and the object is to improve the competitive force of industry and maximize the profit. In the future research, we will seek for the cooperation with the leading enterprises in the fish product transportation and sale industry actively, and apply the forecasting method to the former orders of the enterprises to conclude the feature of order data on the network, then validate the short-term demand forecasting of enterprise in the future via the order feature to achieve the object of combining the theory with the practice.

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