Journal of Applied Sciences

ISSN 1812-5654

science alert

ANSInet
an open access publisher
http://ansinet.com

Journal of Applied Sciences 13 (11): 1970-1974, 2013
ISSN 1812-5654 / DOI: 10.3923/jas.2013.1970.1974

Study on Forecasting the Berthing Time of the Ships in the Port

[1]Xuefei Li, [2]F. Soler-Flores, [2]N. González-Cancelas and [2]A.C. Orive
[1]School of Traffic and Transportation, Beijing Jiaotong University, Beijing, 100044, China
[2]Escuela Técnica Superior de Ingenieros de Caminos, Universidad Politécnica de Madrid, Madrid, 28040, Spain

Abstract: Forecasting the berthing time of the ships has a great significance to the operation management and task arrangement in the port. The factors which influence the berthing time are proposed, the research ideas are designed and the BP neural network, RBF neural network and linear neural network are constructed. A case study which uses the data of Valencia port is analyzed. The outputs of the three neural networks are evaluated and the best neural network is obtained. The simulation results show that the outputs of the neural networks have the high accuracy and conform to the actual work needs.

Key words: Ship, berthing time, neural network, forecast

INTRODUCTION

The port management departments of different ports have paid much attention to the berthing time of the ships in the port and have taken a variety of measures to shorten the berthing time of the ships, in order to improve the utilization efficiency of the berths and improve the operating efficiency of the port. The total berthing time of the ships in the port is constituted by the productive berthing time, unproductive berthing time and natural factors and thus not only includes human factors but also includes the impact of natural factors. How to forecast the berthing time of the ships in the port correctly by using the information that we have will have great significance and important function to improve the operation efficiency and increase port handling capacity.

Over the analysis of the research literatures about the berthing time of the ships in the port in China and foreign countries, we could find that most of the previous researches are overview reports and qualitative studies which only propose some advice and measures but lack of quantitative researches (Xu and Wang, 2007; Chen, 1999). The quantitative researches will have a more practical sense for the actual operation of the port and provide a better reference for the orderly conduct of the actual work. At the same time, because there are many factors which influence the berthing time of the ships in the port, we need to adopt advanced forecasting methods in order to consider these factors comprehensively and get the better forecasting results. The artificial neural network is an advanced optimization method which could simulate human thinking activities and find the internal relations between different factors. Therefore, we adopt the artificial neural network to forecast the berthing time of the ships in the port.

THE FACTORS OF THE BERTHING TIME OF THE SHIPS IN THE PORT

To study the berthing time of the ships in the port, we need to use the statistics data which are existent. There are many factors that influence the berthing time of the ships in the port but because restrictions of the port condition or some factors are not included in the statistical works, we do not have these data. Therefore, we will study on the berthing time of the ships in the port by using the existing data.

According to the analysis of existing statistics data, we pick out the four kinds of data as the factors which includes regular line, ship type, berth and start month.

In the regular lines, the goods category is relatively fixed and the tasks are relatively simple, however in the nonsked lines, there are more random factors and may need more time to complete the tasks.

The different ship types will also affect the berthing time of the ships in the port. The large ships require long operating time and the loading and unloading process is complex, thus there may be a longer berthing time.

The berth will influence the berthing time of the ships in the port. The berths in different position will have different conveniences for the short handling tasks and use different time to complete the tasks.

The start month refers to the time that the ship enters the port. In different start month, the port has different

Corresponding Author: Xuefei Li, School of Traffic and Transportation, Beijing Jiaotong University, Beijing, 100044, China

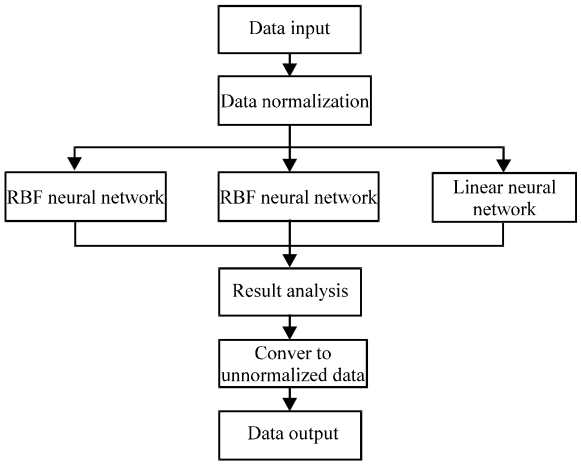

Fig. 1: Research ideas of this paper

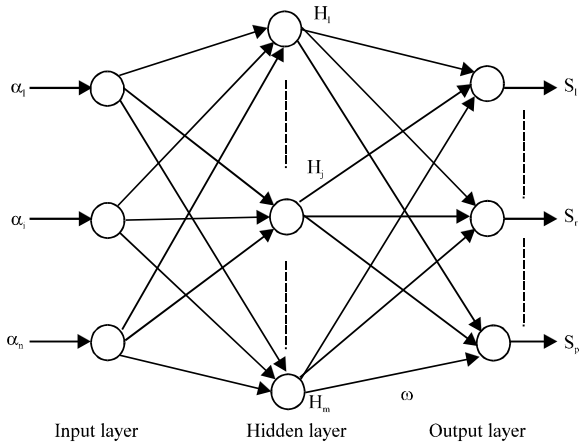

Fig. 2: The structure of the BP neural network

busy levels. Therefore the start month has a great impact on the tasks process and will affect the berthing time of the ships in the port.

Based on the above analysis, we select four factors: regular line, ship type, berth and start month as the input parameters of the neural networks.

STRUCTURE OF THE ARTIFICIAL NEURAL NETWORKS

The artificial neural network is a new subject which is quickly developed in the late 1980s. The artificial neural network is an abstraction and simulation of the biological neural structure and is a network structure which could repeat and reproduce the thought process of the humans and has the functions of learning, associating, memory and pattern recognition and a very wide range of application.

Towards the problem of forecasting the berthing time of the ships in the port in this paper, the artificial neural network could find the internal relations between the berthing time of the ships with the regular line, ship type, berth and start month, in order to ensure the forecast accuracy in the future. There are many types of neural network models and the different models have different adaptability, thus the difference between the results obtained may be relatively large. In order to guarantee the accuracy of the forecasting results, we use the BP neural network, RBF neural networks and linear neural network (You *et al*., 2004; Liu, 2012; Meng and Lv, 2012) to predict the berthing time of the ships in the port and pick out the most suitable model of the problem as the optimal network model, the research ideas of this paper is shown in Fig. 1.

Back propagation neural network model. Back Propagation Neural Network has a powerful classification and forecasting capability and is able to approximate a nonlinear function and is a multi-layer feed forward neural network which is based on the back propagation algorithm. BP neural network generally has the topological structure of three layers or more and includes the input layer, hidden layer and output layer, where the hidden layer may be a multi-layer, the structure of the BP neural network is shown in Fig. 2.

There are some mathematical relationships between the different layers in BP neural network and the activation function in the BP neural network is generally sigmoid function. The activation function includes the logarithmic sigmoid function:

$$f(x)=\frac{1}{1+e^{-x}}$$

and tangent sigmoid function:

$$f(x)=\frac{1-e^{-x}}{1+e^{-x}}$$

We adopt the logarithmic sigmoid function in this paper and the output is one-dimensional data. The output function of the BP neural network is given in Eq. 1:

$$s=\frac{1}{1+e^{-\sum_{j=1}^{m} w_{jr} H_j}} \quad (1)$$

where, s is the output of the BP neural network; H_j is the output of the hidden layer; w_{jr} is the connection weights between the hidden layer and the output layer.

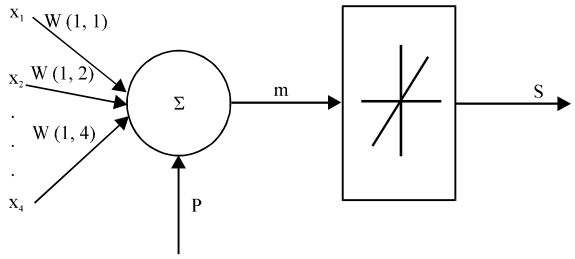

Fig. 3: The structure of the linear neural network

Radical basis function neural network model. RBF neural network is a novel neural network which is proposed by Moody and Darken in 1989. RBF neural network is an efficient feed forward neural networks which is based on the function approximation theory and has the best approximation properties and the simple structure, so RBF neural network is widely used in many research areas.

The basic structure of the RBF neural network is similar to the BP neural network which is shown in Fig. 2 but the difference between the two neural networks is that the RBF neural network uses the radial basis function as the activation function in the hidden layer neurons.

The output function of the RBF neural network is given in Eq. 2:

$$s = \sum_{i=1}^{m} w_{jr}\, \varphi_j\left(\left\|a - Z_j\right\|\right) = \sum_{i=1}^{m} w_{jr} \exp\left(-\frac{\left\|a - Z_j\right\|^2}{2\delta_j^2}\right) \quad (2)$$

where, $\varphi_j(x)$ is the activation function between the input layer and the hidden layer; a is the input vector; Z_j is the center of the radial basis function; δ_j is the width of the radial basis function.

Linear neural network model. The linear neural network is a network with one or more neurons, including single-layer network and multi-layer network. The linear neural network is different from the perceptron network and each activation function of the neuron is a linear function, thus the output of the neural network can an arbitrary value. The single-layer linear neural network is used in this paper and its structure is shown in Fig. 3.

The linear neural network adopts the Widrow-Hoff learning rule which is also called LMS (Least Mean Square) algorithm to adjust the network weights and threshold. The output of the linear neural network is given in Eq. 3:

$$s = \text{purelin}(Wx+P) = Wx+P \quad (3)$$

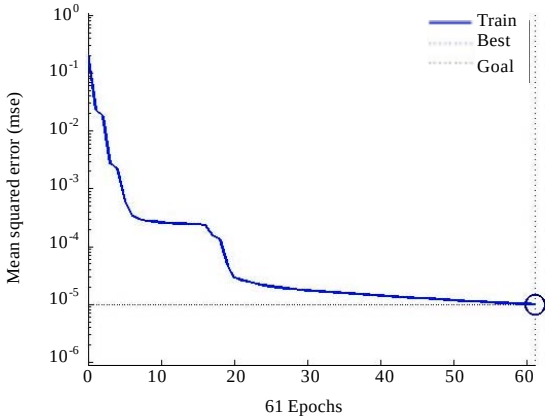

Fig. 4: Training process of the BP neural network

where, purelin (•) is the transfer function of the linear neural network; x is the input vector of the neurons; W is the weight vector of the neurons; P is the threshold of the neurons.

Output errors of the three neural networks. In order to evaluate the performances of the proposed BP neural network, RBF neural network and linear neural network, we define the error function of the three neural networks as following, see Eq. 4:

$$mse = \frac{1}{2}\sum (s-Q)^2 \quad (4)$$

where, mse is the output error of the neural network; Q is the expected output of the neural network; s is the actual output of the neural network.

FORECASTING THE BERTHING TIME OF THE SHIPS IN VALENCIA PORT

In this study, we take the Valencia port in Spain as the study object, analyze and calculate the data of the berthing time of the ships in Valencia port from the year of 2008 to 2011. We randomly select 500 sets of data as the training samples of the neural network and randomly select 50 sets of data as the testing samples.

We define the output of the neural network as showed in Table 1:

The part of the data of the training samples and the testing samples are shown in Table 2 and 3.

We study following the research ideas shown in Fig. 1 and use the Matlab software to program. We put the data of the completely training samples and testing samples input to the proposed neural network models and get the computed results which are shown in Fig. 4-6.

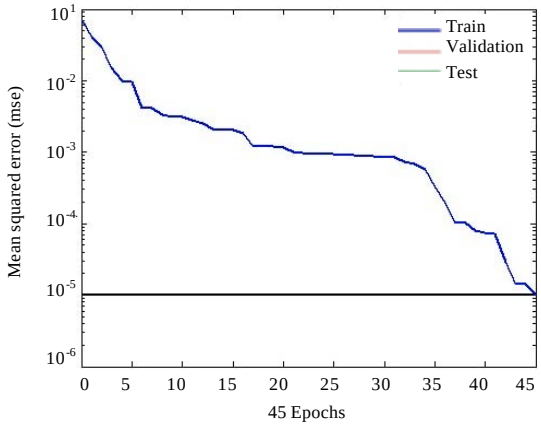

Fig. 5: Training process of the RBF neural network

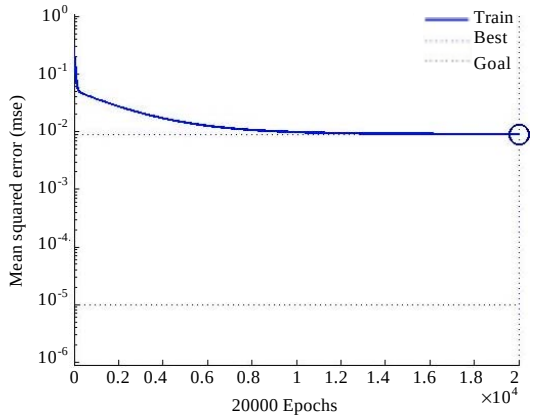

Fig. 6: Training process of the linear neural network

Table 1: The form of the neural network output

Actual berthing time (h)	Output value
0-8	1
8-16	2
16-24	3
24-	4

By comparing the outputs of the three neural networks, we can see that the BP neural network reaches the mean squared error of 10^{-5} in 61 epochs, the RBF neural network reaches the mean squared error of 10-5 in 45 epochs, while the linear neural network reaches the mean squared error of 10^{-2} in 20000 epochs which is the maximum number of calculation. Therefore, the RBF neural network achieves the accuracy requirement in a minimum number of calculated times and we choose the proposed RBF neural network as the optimal neural network.

We adopt the proposed RBF neural network to simulate 50 testing samples and we obtain the results which are shown in Fig. 7.

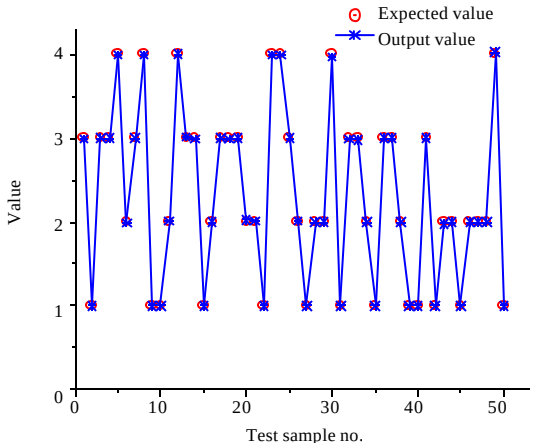

Fig. 7: Fitting result of the RBF neural network

Table 2: Part of the training samples

No.	Regular line	Ship type	Berth no.	Start month	Berthing time
1	91	28	31	9	2
2	123	28	27	1	4
3	76	28	17	7	2
4	39	18	3	2	1
5	58	29	31	12	2
6	13	29	14	3	1
7	128	29	31	7	4
8	121	28	33	2	3
9	63	29	17	2	2
10	100	29	40	10	3
11	46	35	7	6	1
12	10	5	11	9	1
13	102	28	7	12	3
14	127	29	31	5	4
15	77	28	17	1	2
16	85	29	31	4	2
17	99	29	40	3	3
18	27	29	17	10	1
19	82	29	31	3	2
20	134	29	31	2	4

Table 3: Part of the testing samples

No.	Regular line	Ship type	Berth no.	Start month	Berthing time
1	108	29	31	5	3
2	11	34	3	1	1
3	113	28	3	11	3
4	117	34	10	7	3
5	125	12	29	4	4
6	84	29	31	12	2
7	122	30	9	8	3
8	138	16	18	6	4
9	50	12	21	9	1
10	32	11	29	5	1

We can see from Fig. 7 that the RBF neural network has high computing accuracy and has the good fitting results with the 50 testing samples, so the RBF neural network can be used as the neural network that forecasting the future berthing time of the ships in the port.

CONCLUSION

This study analyzes the importance of forecasting the berthing time of the ships in the port and proposes four factors which affect the berthing time of the ships and are used as the input parameters of the neural networks. We build three neural network models which include the BP neural network, RBF neural network and linear neural network and analyze a case study which uses the berthing time of the ships data in Valencia port from the year of 2008 to 2011. We get the outputs of the three neural networks and through the comparative analysis, we find that the RBF neural network achieves the accuracy of the demand in a minimum number of calculations and thus we choose the RBF neural network as the best neural network in our research. We can use the proposed RBF neural network to forecast the future berthing time of the ships in the port. The constructed neural network model has a good portability and could also be applied to the other ports in the forecasting work of the berthing time of the ships in the port and provide the support for the orderly conduct of the port operation.

ACKNOWLEDGMENT

The authors are grateful for the support and assistance of Departamento de Ingeniería Civil. Transportes, Escuela Técnica Superior de Ingenieros de Caminos, Universidad Politécnica de Madrid (Spain) and School of Traffic and Transportation, Beijing Jiaotong University (China). This research is supported by the Fundamental Research Funds for the Central Universities (2012YJS054).

REFERENCES

Chen, N., 1999. Berthing time analysis of ships. J. Wuhan Trans. Univ., 23: 303-305.

Liu, J.J., 2012. Study on safety stock forecasting for chain retail enterprises based on BP neural network. Logistics Technol., 31: 326-329.

Meng, J. and Z.B. Lv, 2012. A forecasting model for road traffic accident based on RBF neural networks. J. Changshu Inst. Technol., 26: 86-90.

Xu, J.H. and F. Wang, 2007. Time factor in liner shipping service. J. Dalian Maritime Univ. (Soc. Sci. Edn.), 6: 55-59.

You, B.S., M.Z. Wang and S.L. Xiang, 2004. A linear artificial neural network model for the prediction of discharge of groundwater. J. Guizhou Univ. Technol. (Nat. Sci. Edn.), 33: 60-62.