

# Layout planning of D port functional area based on throughput prediction

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**Abstract**—Since 2013, the implementation of the national “Belt and Road” policy, the coastal areas to promote foreign economic and trade, have begun to launch the planning and layout of the port. This paper takes D port as the research object, and studies its throughput prediction and functional area layout planning to guide D port health and effective planning. Port throughput is an important indicator reflecting the development of the port and has a major impact on port development planning. This paper takes D port as the research object, uses BP (Back Propagation) neural network to predict the D port throughput, and uses the predicted results to plan the area of each functional area in the port area for three years. Finally, the SLP (Systematic Layout Planning) was used to study the D port functional area layout planning, and the final scheme was determined by weighted factor comparison method.

**Keywords**- throughput analysis, prediction, SLP method, BP neural network, port layout planning

## I. INTRODUCTION

Since the 18<sup>th</sup> National Congress, China has implemented the “One Belt, One Road” internationalization strategy, which has highlighted the importance of coastal port development to a certain extent. The 21<sup>st</sup> century is the century of the ocean. The development of the marine economy is a new growth point for China's economic growth and also contributes to the province's new and old kinetic energy conversion strategy. Under this circumstance, we must fully realize that the development along the port is a very important strategic position in the national economic strategy.

If the port throughput expectation is too large, it will cause idle infrastructure in the port and waste of investment funds. If the port throughput is too small, it will cause overload operation of the port, which is not conducive to the maintenance of facilities and equipment in the port. Workers' overworked work increases fatigue and reduces work efficiency, which in turn affects user satisfaction. Reasonable and effective predictions must be made to make the port comprehensive, healthy and sustainable. The BP neural network prediction method introduced in this paper is a widely

used multi-layer feed forward neural network with very powerful computing power. Quantitative analysis methods are mainly used in research methods, including data collection method, inductive analysis method and investigation research method.

## II. A SUMMARY OF THEORETICAL RESEARCH ON BP NEURAL NETWORK AND SLP METHOD

### A. The concept and principle of BP neural network

The structure of the BP network is very simple. The most typical mode structure includes an input layer, a hidden layer, and an output layer. The input layer is used for data input, and the hidden layer is used for processing. The data, the output layer is the expression of the network output. BP neural network is the most widely used neural network in multi-layer feed forward neural networks. BP neural network has very powerful computational ability. By training and grasping the mapping relationship between input and output variables of sample data, it can approach a certain function [1]. The learning process of BP neural network mainly consists of two stages: forward propagation and back propagation.

Each of the samples contains two parts: the input value and the expected output value; when the data is passed between adjacent layers, it needs to be processed in combination with the transfer function, the connection weight and the threshold; then, the output values of the input samples of each group are correspondingly compared the expected output values and calculate the total error of all samples. If the error does not reach the ideal level or the number of iterations is not enough, then the second stage is the back propagation, so that the network can re-adjust the connection weight of each neuron. Threshold, adjust the output error to the minimum, so that the network output value is as close as possible to the value given by the actual sample [2].

### B. SLP method overview

1) *The concept and principle of SLP.* The SLP method is also called the system layout design method. This method is

mainly to establish a correlation diagram indicating the degree of association between each work unit. According to the volume of the building, the various sections are reasonably arranged, and then the weights are given according to the degree of closeness of each section. Then, by experimenting with various schemes and evaluating, finally selecting the highest score layout scheme as the best solution [3].

2) *Basic operation steps and basic elements analysis of SLP method.* There are many factors that affect the SLP method. The basic elements can be summarized into product, Quantity, Route, Serve, Time, where product and output are everything. Basis of other conditions or elements [4].

The specific steps of the SLP method are as follows:

(1) Determination of the five elements. Fully collect data to determine the specific operating unit and five elements, namely product, production, production route, auxiliary service department, time.

(2) Establish a work unit area correlation diagram.

(3) The initial program was produced. After the work area correlation map is obtained, several preliminary schemes are formed by adjusting and modifying the work unit area correlation map.

(4) Program evaluation and selection. Based on the actual situation, the analysis of the implementation technology, operating costs and other factors, the evaluation of the program using a reasonable evaluation method, the selection of the highest-scoring alternatives, and thus the optimal solution.

### III. D PORT AREA FUNCTIONAL AREA LAYOUT PLANNING STATUS

#### A. D port area specific function settings

D port including Dongjiakou mouth operation area reserved for the development and operation of pawn Bay area. Among them, Dongjiakouzuo operation area is mainly based on bulk dry bulk cargo and general bulk cargo transportation with liquid bulk cargo transportation; the land area of the port area is arranged from the sea to the land as the terminal operation area and the reserved development area, according to the port production operation. Need to arrange business districts, financial districts and other logistics support service areas in the port area. The terminal operations are divided into bulk dry bulk terminal operation area, grocery terminal operation area and liquid bulk terminal operation area; logistics area mainly has multimodal transportation and transportation area; logistics support service area includes financial service area and port business area.

#### B. D port area current development status

D The port area is currently a port area under construction. Due to the influence of the “One Belt, One Road” national policy, the port development is very rapid, the throughput is growing rapidly, and the total throughput is increased by nearly 43% compared with the planned time. See Table I for details.

TABLE I COMPARISON BETWEEN THE ORIGINAL PLAN AND THE ACTUAL VALUE WEIGHT(TEN THOUSAND TONS)

Type of goods	Planning plan (2015)	Actual value (2015)
Wood	300	1000
Metal ore	4900	6100
coal	2100	2900
Refined oil and its products	320	520
other	180	295
Total throughput	7600	10815

As can be seen from Table I above, due to the rapid development of the port, the throughput has increased sharply, the wood throughput has increased by 7 million tons compared with the predicted value, which is more than three times the original; the actual value of metal ore throughput has increased by 12 million tons from the predicted value; the actual value of coal throughput increased by 8 million tons compared with the predicted value; the actual value of refined oil products and products increased by 2 million tons compared with the predicted value; the actual throughput of other goods also increased by 1.15 million tons than the predicted value. The total throughput is 32.15 million tons, which is more than 1.4 times the original predicted value.

### IV. PORT THROUGHPUT FORECAST

#### A. Prediction of Port Throughput by BP Neural Network Prediction Method

The BP neural network has at least one hidden layer. In the actual neural network construction process, the most suitable number of nodes is determined by the experience and trial and error method. The reference model is generally determined to determine the approximate number of intervals, and the trial calculation is performed one by one [5]. The neural network structure is shown in Fig 1.

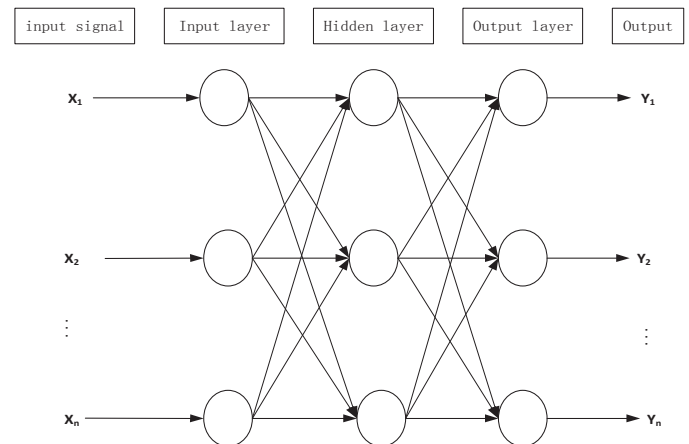


Figure 1 Neural network structure diagram

#### B. BP neural network algorithm test

Taking food and wood as the output vector as an example, the total import and export trade in Shandong Province, the increase in the primary industry in Shandong Province, and the

increase in the secondary industry in Shandong Province are input vectors, through forecast of port grain and timber for three years.

The grain/wood is used as the output vector, the total foreign trade of Shandong Province, the added value of the primary industry in Shandong Province, and the added value of the secondary industry as the interface of the input vector network training. The training error curve is shown in the figure. In MATLAB2017b, the training time needs to be guaranteed. The error continues to decrease and the training is terminated when the effect cannot be improved to prevent entry into the learning situation. It is known from the training interface diagram that when the network trains to step 345, the network terminates the training. As shown in Fig 2.

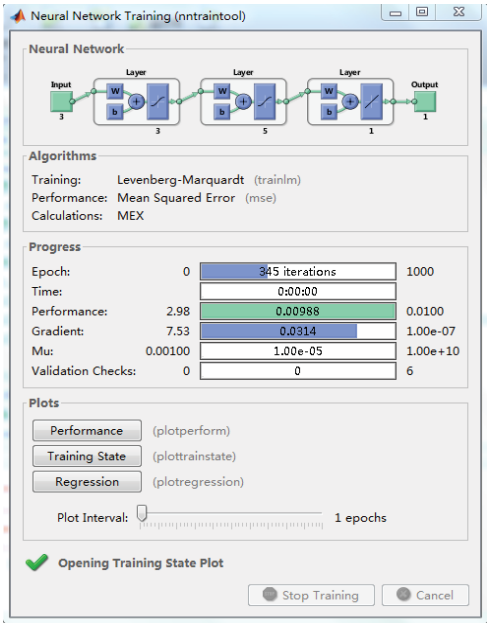


Figure 2 Network training cross section

### C. Port cargo throughput forecast

In order to ensure the correctness of the paper results, the throughput of each of the four quarters of 2017 is predicted. Then consider 2017's throughput as a whole to predict it. Compare with the results of the four quarters. Verify that you can use the annual throughput to make predictions for easy calculations while ensuring the accuracy of the calculations.

Because the construction of the port and the port area is a large system project, if the forecast is only based on the quarterly throughput, the increased throughput will not be very large, and it will be insignificant. Therefore, it is helpful to predict the throughput ratio in the past year. Plan the area of each functional area in the port area.

The 2017 full-year data includes the added value of the primary industry in Shandong Province, the added value of the secondary industry, and the total import and export trade volume of Shandong Province into the well-trained BP neural network. The following training results are obtained as shown in Fig 3, Fig 4.

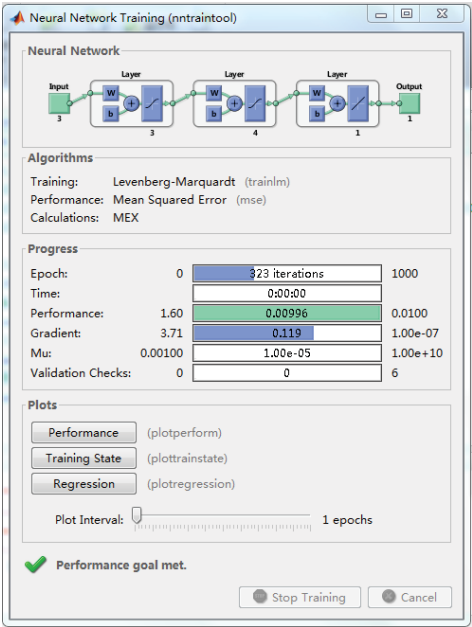


Figure 3 Network training cross section

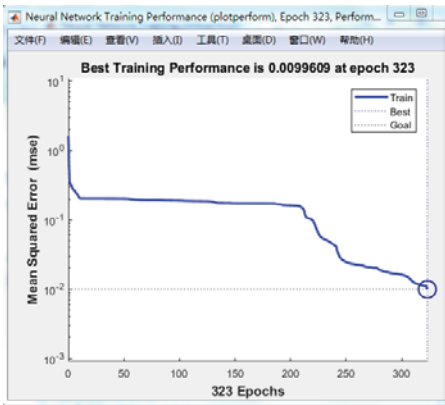


Figure 4 Training error curve

The result is:  $C=1.6381 \times 10^3$ .

In 2017, the annual wood throughput was 16381 million tons. Compare the sum of the throughput forecasts for the four quarters of 2017 with the actual throughput for 2017, as shown in Table II, Table III.

TABLE II THE SUM OF ANNUAL AND FOUR SEASONS THROUGHPUT

Annual throughput	The sum of throughput in four quarters	Difference	Error rate
1638.1	1639.2	1.1	0.07%

TABLE III SUM OF ANNUAL AND ACTUAL THROUGHPUT

Annual throughput	Actual value	Difference	Error rate
1638.1	1633	5.1	0.31%

It can be seen from the above table that the error rate is extremely small, so it can be predicted according to the throughput of one year.

#### D. Port cargo throughput in the next three years

Substitute the data obtained from the survey into the established BP neural network model to obtain the throughput of wood, metal, coal, petroleum products and other goods in the next three years. The list is as shown in Table IV.

TABLE IV SUMMARY OF PORT CARGO THROUGHPUT FOR THE NEXT THREE YEARS

kind time	wood	metal	coal	Petroleum products	Other goods
2018	1899.3	7712.3	4156.8	675.7	386.2
2019	2120.4	7212.3	4349.7	692.8	399.8
2020	2412.8	8356.3	4963.6	721.7	415.7

#### V. APPLICATION OF SYSTEMATIC FACILITIES ARRANGEMENT METHOD IN PORT LAYOUT PLANNING

##### A. Five Elements Analysis of SLP

1) *Logistics object analysis.* In the D port planning, the logistics object refers to the quantity and type of goods entering and leaving Port D. By analyzing the quantity and type of main import and export goods and the service scope of D Port and the neighboring related ports, it is concluded that the types of goods entering and leaving mainly include Bulk timber bulk operation area, coal bulk cargo operation area, metal ore bulk cargo operation area, refined oil and product oil tank operation area, and grocery operation area.

2) *Material flow analysis.* The flow of goods in D port mainly refers to the total amount of logistics of various types of goods entering and leaving the port, which is calculated by calculating the weight and type of general cargo. Depending on the means of transport, it can be divided into shipping, pipeline transportation, rail freight volume and road freight volume.

Logistics operation process analysis. The operation process of Port D mainly refers to the operation or treatment that the goods entering the port need to pass through in the port area. The specific process is shown in Fig 5:

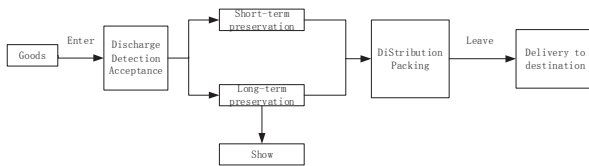


Figure 5 Flow chart of cargo in port

3) *Auxiliary service function analysis.* The auxiliary service function is mainly in the D port area mainly refers to the business district, financial service area and related commercial supporting areas. The auxiliary function can be the rapid development of the port area, improve the level of construction and help the development of the economy in the hinterland.

4) *Logistics technology analysis.* Since D Port relies on shipping and is equipped with land transportation and a small portion of air transportation to promote the development of logistics and other business in the port area, it must be

equipped with relevant loading and unloading settings, transportation tools and operating equipment.

##### B. Drawing area correlation diagram

According to the map of D port functional area location and the calculated area of each functional area of D port, the area of each functional area in the next three years is 44250 square meters of timber working area, and the area of metal ore working area is 44730 square meters. 83025 square meters, the area of finished oil and product operation area is 7200 square meters, and the area of other cargo operation area is 16500 square meters. The ratio of area is 6.1:6.2:11.6:1:2.3. The area-related diagram is shown in Fig 6.

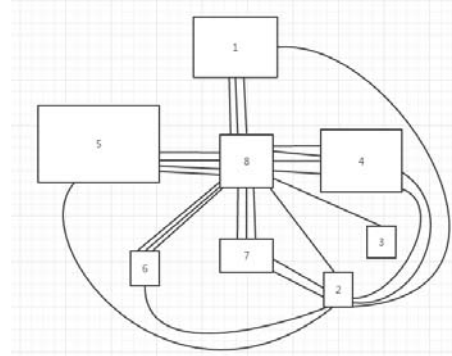


Figure 6 Area correlation diagram

Note: 1-Timber bulk cargo operation area 2-Business area 3-Financial service area 4-Metal ore operation area 5-Coal operation area 6-Product oil operation area 7-Other bulk operation area 8-Multi-test intermodal transportation area

##### C. Determination of the preliminary plan

According to the above calculation results of the new work area, the area of the work area is reasonably increased. In order to improve the feasibility and practicality of the initial plan, combining the above three correction factors, the actual status of D port, and the area map of D port function area, the following three preliminary options that meet the requirements can be obtained Fig 7, Fig 8, Fig 9.



Figure 7 Programme one

Note: black line is road, green line is green belt, 1-wood bulk cargo operation area, 2-business area, 3-financial service



area, 4-metal ore operation area, 5-coal operation area, 6-product oil operation District, 7-Other Bulk Cargo Operation Area, 8-Multi-Test Intermodal Transportation Area



Figure 8 Programme two



Figure 9 Programme three

### D. Program evaluation

For the three options obtained, we use the weighted factor comparison method to evaluate. As shown in Table V.

TABLE V EVALUATION LEVEL OF EACH LAYOUT PLAN

Serial number	factor	Scheme 1 level	Scheme 2 level	Scheme 3 level
1	Practicality and versatility	A	A	A
2	Logistics efficiency	E	A	A
3	Logistics handling efficiency	E	I	A
4	Storage efficiency	A	A	A
5	Site utilization	A	A	A
6	Auxiliary department's overall efficiency	A	A	A
7	Work environment with employee satisfaction	A	A	A
8	Safety management	A	A	A
9	Coordination with long-term planning	A	A	A
10	other	A	A	A

This leads to:

Program 1 total score:  $T1=4*4+2*4*2+3*2*4+3*2*3=74$

Program 2 total score:  $T2=4*4+2*4*2+3*3*4+3*2=74$

Program 3 total score:  $T3=4*4+2*4*2+3*4*4=80$

From the above results, we know  $T3> T2= T1$ .

Therefore, the third option is the best solution as shown in Fig 10.



Figure 10 Optimal plan layout of D port area

## VI. CONCLUSION

This paper takes the functional area layout planning in the port planning process as the research object. The key research is based on the BP neural network prediction method to predict the port throughput, and the area that should be planned for each functional area in the next three years, and the D port area project. The SLP method is used to analyze the layout of the functional area, and the optimization scheme of the D port functional area layout is obtained, which verifies the feasibility of the method.

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