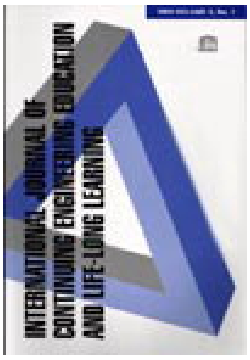

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Yuanyuan Kong, Yunxia Li, Yang Liu

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A balanced allocation of network teaching resources in higher vocational colleges based on demand prediction

Yuanyuan Kong*

Office of Development and Planning,
Shandong Polytechnic,
Jinan 250104, China
Email: yuanyuank@mls.sinanet.com
*Corresponding author

Yunxia Li

Department of Civil Engineering,
Shandong Polytechnic,
Jinan 250104, China
Email: 40819448@qq.com

Yang Liu

Planning and Finance Department,
Qilu University of Technology,
Jinan 250353, China
Email: liuyang@qlu.edu.cn

Abstract: Because the traditional teaching resource allocation method has the problems of low accuracy of resource demand prediction and low balance of resource allocation, this paper studies a new balanced allocation method based on demand prediction. The data of network teaching resources are collected, and the nonlinear demand prediction model of network teaching resources is constructed by using the principle of time series. Based on the output results of the demand prediction model, the resource surplus in the network teaching resource allocation node is obtained, the dynamic weight results of network teaching resources are calculated, and the balanced allocation function of teaching resources is constructed. The experimental results show that this research can achieve the accurate prediction of the demand for teaching resources, and improve the balance of resource allocation, with the distribution balance parameter reaching 0.98.

Keywords: demand prediction; higher vocational network teaching; teaching resources; balanced distribution.

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Biographical notes: Yuanyuan Kong received her Master's in Technological Economics and Management from Nankai University in 2006. She is currently a Lecturer and the Deputy Director of Office of Development and Planning of Shandong Polytechnic. Her research interests include project management and vocational education studies.

Yunxia Li received her Master's in Structural Engineering from Lanzhou Jiaotong University in 2007. She is currently an Associate Professor in the Department of Civil Engineering of Shandong Polytechnic. Her research interests include Structural engineering and construction materials.

Yang Liu graduated from Shandong University of Economics with a Bachelor's in 2004 and graduated with a Master's from Shandong University in 2009, majoring in Financial Management, and Business Administration Direction. She is currently a Lecturer and the Deputy Director of the Planning and Finance Department of Qilu University of Technology (Shandong Academy of Sciences). Her research interests include college financial management, budget management, charge management and internal control construction.

1 Introduction

In the modern society with developed information and continuously improved technical level, various industries rely on the development of mobile network technology, and emerging network technology is gradually applied to the online teaching platform of major universities (Xu and Fan, 2020). However, with the wide application of online learning platform, the urgent problem to be solved is the mismatch between the amount of teaching resources and demand. Therefore, when vigorously carrying out online learning, achieving a balanced distribution of teaching resources is a top priority (Jiang, 2021). However, because the traditional network teaching resource allocation method cannot accurately analyse the needs of students for learning resources, the waste of teaching resources often occurs (Sg and Ss, 2020). Therefore, reasonable classification of teaching resources can effectively solve this problem.

Wu et al. (2019) propose a balanced distribution method of network teaching resources based on the induction method. This method builds a mathematical model of the distribution target of higher vocational network teaching resources, solves the target model, and uses the induction method to gradually increase teaching resources and teaching plans. In the process, the optimal allocation scheme is obtained. However, this method has the problem of poor distribution balance. Wang et al. (2019) propose a balanced allocation method of Higher Vocational network teaching resources based on historical data. This method collects the historical data of Higher Vocational network teaching resources, and on this basis, constructs a comprehensive evaluation index of Higher Vocational network teaching resources allocation. According to the evaluation index, the final evaluation result is obtained. However, it is difficult for this method to effectively predict the multi-party demand of Higher Vocational network education resources, so the final allocation result is not ideal. Tang et al. (2019) put forward a balanced allocation method of Higher Vocational network teaching resources based on fog computing, which uses the fog computing method to calculate the task priority of Higher Vocational network teaching resources. According to the result of priority calculation, the priority list is constructed, and the network teaching resources are allocated according to the result of priority list. However, due to the balanced distribution, this method still cannot meet the demand.

Since the above three traditional methods cannot solve the problem of unbalanced resource demand prediction and allocation, a balanced allocation of resources is carried out on the basis of demand prediction. The main technical routes of the research are as follows:

Firstly, the data set of teaching resources is constructed and put into the time series method to construct the nonlinear demand prediction model of network teaching resources. The ε-insensitive function and relaxation variable are introduced into the model to transform the model and improve the accuracy of demand prediction. According to the Lagrange multiplier and the principle of support vector machine, the nonlinear teaching resource demand prediction model is solved, and the prediction results of teaching resources are obtained.

Secondly, based on the prediction results of different students' demand for teaching resources, the resource allocation proportion in the network node is calculated, and the resource surplus in the network teaching resource allocation node is obtained. The dynamic weight results of network teaching resources are calculated according to the resource demand results. According to the weight calculation results and the delay of resource allocation, the resource balanced allocation function is constructed, and the balanced allocation scheme of network teaching can be obtained by solving the function.

Finally, a comparative verification experiment is carried out.

2 Demand prediction of network teaching resources

For the balanced distribution of effective teaching resources, we need to effectively predict the resources needed by different students according to their learning conditions. In the process of this research, we use the time series method to complete the demand prediction.

Based on the network teaching resource data of a large vocational college, data acquisition and unified formatting processing are carried out, and the processed data are transmitted to data processing. Then the number of resources required at time T is thus calculated. The total amount of data is 15GB. For the balanced allocation of teaching resources, it is necessary to analyse different kinds of needs (Medina et al., 2018; Sharaff and Nagwani, 2020)[8-10].

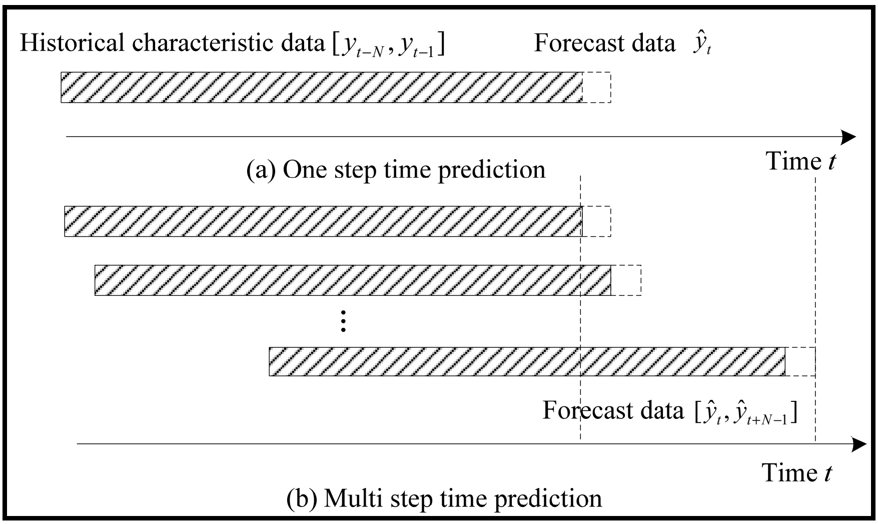
The data set of network teaching resources in higher vocational colleges is defined as $D = \{(x_i, y_i) \in R^N \times R_i = 1, ..., 1\}$, where x_i represents N-dimensional input variables and data values of the past N times; y_i represents the output variable result and represents the data value of the next time (Wang et al., 2021; Yang, 2020; Liu, 2019). Because the teaching resource data set is closely related to the time series, the time series method is used to calculate the demand of teaching resources and complete the demand prediction. The principle of time series prediction is shown in Figure 1.

Based on the above prediction principle, the dimension of the data is reduced by the nonlinear mapping principle of kernel function. Based on data set D, the expression of the nonlinear demand prediction model is:

$$f(x, w) = \sum_{i=1}^{1} w_i \times \phi(x) + b \tag{1}$$

In equation (1), D is the resource data set; $w = [w_1, w_2, ..., w_l]$ represents the demand weight; $\phi(x)$ represents the demand feature mapping function; b represents the operation deviation value of the model.

Figure 1 Principle of single step and multi-step time prediction



According to the above model, ε-insensitive function $g_\varepsilon(.)$ is introduced to convert the model, and finally the model can be solved by support vector machine. The converted model is as follows:

$$\min_{w,b} \frac{1}{2}\|w\|^2 + C\sum_{i=1}^{1} g_\varepsilon\left(y_i - f\left(x_i - w\right)\right) \tag{2}$$

In order to improve the effectiveness of teaching resource demand prediction, the expression of ε-insensitive function is constructed. By setting the threshold, the general expression is obtained:

$$g_\varepsilon(.) = \begin{cases} 0, |z| \le \varepsilon \\ |z| - \varepsilon, other \end{cases} \tag{3}$$

Introduce slack variables to transform the model and get:

$$\min_{w,b,\xi_i,\hat{\xi}_i} \frac{1}{2}\|w\|^2 + C\sum_{i=1}^{1}\left(\xi_i + \hat{\xi}_i\right) \tag{4}$$

where ξ_i and $\hat{\xi}_i$ are relaxation variables.

$$s.t. f\left(x_i, w\right) - y_i \le \varepsilon + \hat{\xi}_i \tag{5}$$

$$y_i - f\left(x_i, w\right) \le \varepsilon + \xi_i \tag{6}$$

$$\hat{\xi}_i \geq 0, \xi_i \geq 0, i = 1, 2, ..., 1 \tag{7}$$

According to the Lagrangian multiplier and the principle of support vector machine, the nonlinear teaching resource demand prediction model can be solved, and the prediction result is:

$$f(x) = \sum_{i=1}^{1} (\hat{\alpha}_i - \alpha_i) \phi(x_i) \phi(x) + b \tag{8}$$

Through the above calculation, the demand of higher vocational network teaching resources is accurately predicted, and the application of the prediction results to the balanced allocation of resources can effectively improve the balance of resource allocation.

3 Resource equilibrium allocation based on demand prediction

According to the above-mentioned resource demand prediction result, the resource is allocated in a balanced manner. First of all, it is necessary to determine the remaining use value of the resources of the allocated node (Pei and Wang, 2021; Kersey, 2019; Wei and Chen, 2019).

Define c as the number of nodes, and R (r_1, r_2, r_m $\cdots$) is the spatial dimension of teaching resource data. Then the proportion of allocated resources in the total resources can be obtained as:

$$\gamma(g) = \frac{c\, R(r_1, r_2, rm \cdots)}{m * \theta(\tau)} \cdot \mu(K) \times o(K) \tag{9}$$

In equation (9), $\theta(\tau)$ is the sum of all teaching resources; $\mu(K)$ represents the amount of K-dimensional teaching resources, and $o(K)$ is the resource data contained in a single assigned task (Chen et al., 2020).

Based on the above calculation results, the ratio of the number of allocated resources in a single resource allocation node to the number of allocated resources in all allocation nodes is calculated:

$$\varsigma(d) = \frac{r_{ij}}{\partial(t)} * \frac{\mu(g) * j(g)}{h(y)} \tag{10}$$

In equation (10), r_{ij} represents the teaching resource data that have been allocated; $\partial(t)$ represents the balance function of teaching resources; $j(g)$ represents the load function of network teaching resources; $h(y)$ represents the number of resources allocated by a single processing node (Shi and Yang, 2020).

The remaining number of resources in the network teaching resource allocation node is obtained to calculate the dynamic weight result of the network teaching resource:

$$RS = \frac{\phi_{(f,j)} * \eta(g) * V(\sigma)'}{\xi(s)} E' \tag{11}$$

where $\phi_{(fj)}$ is the number of resources allocated by the j^{th} node; W' is the dynamic weight of remaining resources; E' is the number of surplus resources; $V(\sigma)$ is the influence function of the residual number of nodes on the load capacity of nodes; $\xi(s)$ is the balance degree of nodes after obtaining the resource s.

According to the dynamic weight calculation results of network teaching resources, set the resource demand as $f(x)$ and calculate the distribution consumption of teaching resources:

$$U = \frac{H * f(x)}{f_j \times m} * p_j f_j \tag{12}$$

In equation (12), H is the heat state of resources, f_j is the duration of interactive phenomenon of teaching resources, and p_j is the probability of interactive phenomenon of resources.

The main factor affecting the occurrence probability of resource interaction is heat. At this time, the consumption index of network teaching resources can be calculated (Chen, 2021):

$$C = \frac{h_j * f_j}{U} \tag{13}$$

In the formula, h_j represents the heat value of resource interaction.

The performance index expression of teaching resource allocation node is as follows:

$$M(F) = \frac{p_c \times p_m}{v_c \times s_c} * H \tag{14}$$

In equation (14), s_c is the performance parameter of the resource allocation node, and p_c represents the ratio of s_c to the CPU performance parameter.

Before construction of the balanced allocation function of network teaching resources, the average delay of the allocation node in the process of resource information transmission should be calculated according to the communication characteristics of the resource allocation node:

$$v_1(i) = \frac{M(F) \times n}{D_{ij}} \tag{15}$$

where D_{ij} represents the transmission delay between the network teaching resource allocation nodes, and n represents the number of allocation nodes in a fixed area (Sathishkumar and Gunasekaran, 2020).

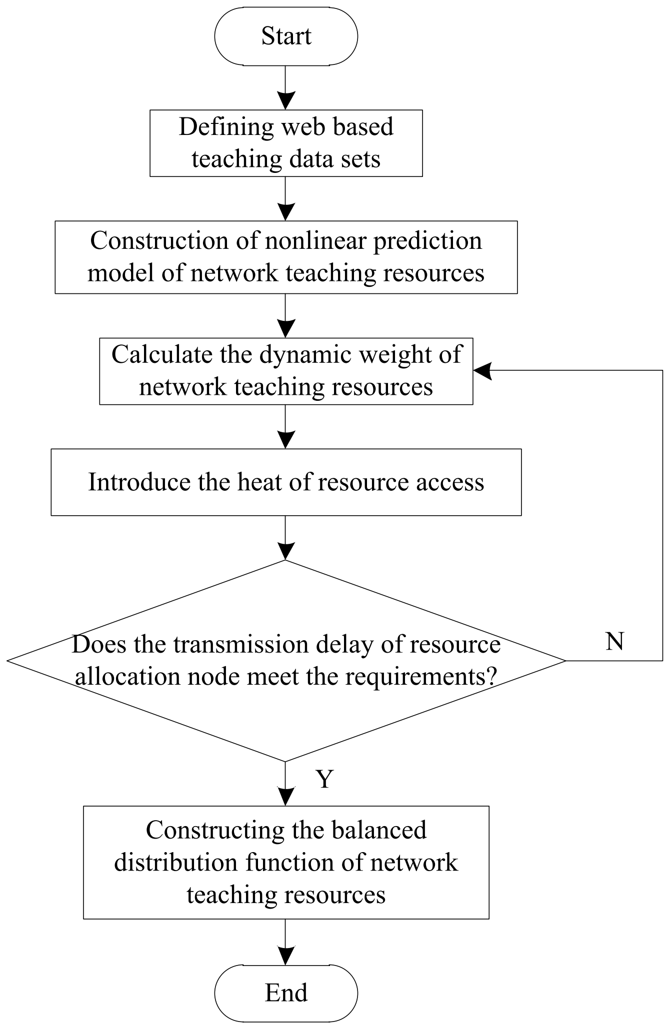
The specific expression is:

$$id_n = \frac{v_1 * s_1 \times p}{f\left(C_{id}, NA\right)} * P_{max} \times \mathrm{P}_{rmd} \tag{16}$$

where v_1 represents the actual transmission delay; s_1 represents the standard transmission delay; C_{id} represents the distribution consumption index of network teaching resources; NA represents the distribution list; P_{max} represents the remaining performance index of the distribution node; P_{rmd} represents the maximum performance index of the distribution node.

According to the calculation result of equation (16), the balanced distribution of higher vocational online teaching resources can be completed. Figure 2 shows the distribution process of higher vocational network teaching resources based on demand prediction.

Figure 2 Distribution process of network teaching resources



4 Experimental verification

4.1 Experimental data

The experimental data come from a teaching resource allocation information website of a higher vocational college in this province. The total amount of experimental sample data is 15GB. Since the experimental sample data come from the teaching website, the experimental sample data are all valid data. Simulation was conducted using Matlab software simulation environment, and experimental data were stored in MySQL for the convenient access to the data.

4.2 Experimental data description

Based on the above experimental data and experimental environment, the simulation comparison experiment was carried out, and the scheme and indicators of the simulation experiment were planned: Taking the prediction accuracy and distribution balance of teaching resource demand as the comparison experimental indicators, the method was compared with the methods of Wang et al. (2019) and Tang et al. (2019).

Demand prediction accuracy of online teaching resources: The prediction accuracy of online teaching resource demand is the closeness between the resource demand predicted by different methods and the actual demand. The higher the prediction accuracy of online teaching resource demand, the stronger the performance of the allocation method.

Network teaching resource distribution equilibrium: the resource distribution equilibrium was verified through the distribution equilibrium coefficient. The value range of the distribution equilibrium coefficient is [0, 1]. The closer it is to 1, the higher the distribution equilibrium is.

4.3 Analysis

4.3.1 Prediction accuracy of network teaching resource demand

As the result of online teaching resource demand has an important impact on the balance of the final resource allocation results, it is necessary to verify the accuracy of teaching resource demand prediction of different allocation methods. Taking the accuracy of resource demand prediction as a performance evaluation index, the method was compared with Wang et al. (2019) and Tang et al. (2019) method. The prediction accuracy of teaching resource demand of the three methods are shown below.

In the prediction results of the three methods, the resource demand prediction accuracy of the proposed method is higher than that of the other two prediction methods. During a total of 10 experiments, the demand prediction accuracy of the proposed method has always remained above 97%, while the highest demand prediction accuracy of the comparative method is 84.5% and 8.5%, respectively. Therefore, it shows that the method in this paper can effectively predict the resource demand and provide strong data support for the balanced allocation of teaching resources.

4.3.2 Comparison of distribution equilibrium

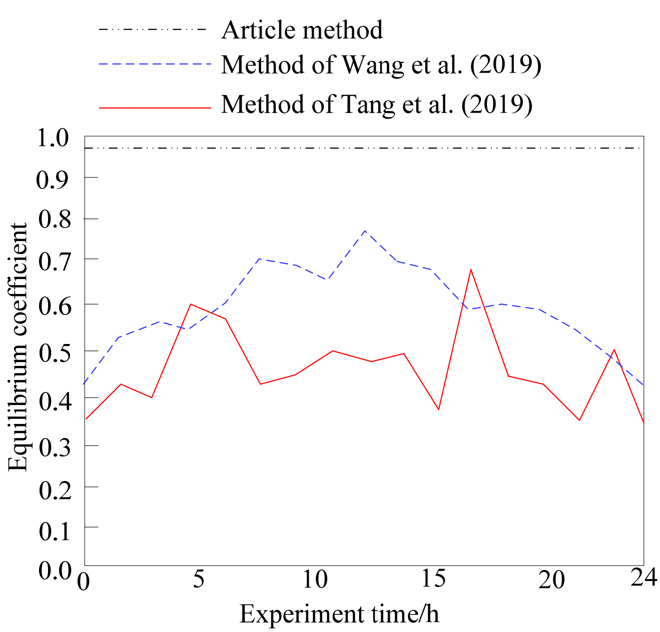
This paper verifies the superior performance of this method in resource allocation with progress one, and directly verifies the balanced allocation performance of this method. Taking the distribution equilibrium coefficient as a reference, this method was compared with two traditional methods. The higher the distribution equilibrium coefficient, the stronger the distribution equilibrium. Figure 3 shows the comparison results of distribution equilibrium of different methods.

According to the comparison results of the distribution equilibrium of different methods shown in Figure 3, during the 24-hour experiment, the distribution equilibrium coefficient of online teaching resources of this method is always stable at 0.98, which is always higher than that of the two literature comparison methods. When the experimental time is 5h, the distribution equilibrium coefficient of this method is 0.98, that of Wang et al. (2019) is 0.54, and that of Tang et al. (2019) is 0.59. When the experimental time is 15h, the distribution equilibrium coefficient of this method is 0.98, that of Wang et al. (2019) is 0.67, and that of Tang et al. (2019) is 0.36. When the experimental time is 24h, the distribution equilibrium coefficient of this method is 0.98, that of Tang et al. (2019) is 0.43, and that of Wang et al. (2019) is 0.37.

Table 1 Numerical of demand predict accuracy

Experiment times/time	*Prediction accuracy/%*		
	Article method	*Method of reference Wang et al. (2019)*	*Method of reference Tang et al. (2019)*
1	97.9	84.5	78.1
2	98.5	76.3	69.7
3	99.2	77.4	66.2
4	98.3	81.2	70.5
5	98.4	69.8	71.6
6	99.1	75.6	68.3
7	98.9	76.4	77.2
8	99.4	80.1	65.9
9	98.6	74.6	72.9
10	98.5	64.1	78.5
Mean value	98.68	76	71.89

Figure 3 Distribution equilibrium results (see online version for colours)



5 Conclusions

In order to achieve the balanced allocation of resources, according to the prediction results of students' resource demand, the balanced allocation method is studied, and the time series method is used to accurately predict the resource demand. This method has high accuracy of resource demand prediction and high resource equilibrium allocation coefficient in resource allocation. Compared with the results of the allocation method based on historical data, the accuracy of resource demand prediction is greatly improved, and the accuracy of demand prediction is 98.68%; Compared with the allocation method based on fog calculation, the resource allocation equilibrium is significantly improved, and the equilibrium coefficient is always maintained at 0.98. Therefore, it shows that the proposed allocation method based on demand prediction has strong practical application performance.

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