The Construction of a Neural Network-Based Reader Satisfaction Evaluation Model for Digital Libraries

Shuya Zhang[1] and Fei Yao[2*]

[1]Central China Normal University Library, Wuhan, 430079, China
zsy9393@ccnu.edu.cn
[2]Zhongnan University of Economics and Law, Wuhan, 430073, China
Corresponding author: Fei Yao, yf_study@zuel.edu.cn

Abstract. Along with the continuous development of Internet technology, digital libraries occupy a very important role in meeting people's reading needs. Digital library reader satisfaction evaluation is a kind of test for library service quality. Therefore, this paper designs a neural network-based reader satisfaction evaluation model for digital libraries, and through empirical analysis, we find the factors affecting reader satisfaction and put forward corresponding optimization suggestions, in order to provide some reference for the improvement of reader satisfaction in digital libraries.

Keywords: neural network; library; reader satisfaction; evaluation; Construction; Digital Art
DOI: https://doi.org/10.14733/cadaps.2024.S11.111-121

1 INTRODUCTION

The concept of satisfaction originates from marketing science, which is a subjective feeling of users after acquiring a service or product by comparing the expected utility with the actual effect[11]. With the deepening of research and the expansion of application fields, user satisfaction has been introduced into the evaluation of library services to comprehensively grasp user needs and provide better services to users. In user satisfaction evaluation, libraries can use the establishment of user satisfaction index models to study users' feelings about library services, which can be used to improve service quality. Neural network technology is a multi-layer inverse algorithm, which can fully exploit the potential value of massive data by means of independent learning and training of objective data, and avoid the influence of human and subjective factors on the evaluation results. Applying neural network technology to user satisfaction evaluation model construction can improve data processing efficiency and obtain better evaluation results, which is a brand new research direction in the library field.The construction of digital art libraries involves the organization, digitization, and dissemination of artworks and related information using digital technology. Digital

art libraries serve as repositories of visual and textual materials related to art, artists, art history, and cultural heritage.

2 CHARACTERISTICS OF USER SATISFACTION OF COLLEGE LIBRARY

1.subjectivity: the essence of satisfaction survey is to investigate the user's subjective feelings about the construction of the library, this feeling will have different feelings because of the user's mood, environment, situation, etc. The changes in these factors are irrational and not easy to control and change[3].
2. Objectivity: User satisfaction is objective regardless of the survey, as long as the users use the library, they must have their own views on a certain aspect of the library, which will not disappear because the library does not pay attention to the user satisfaction survey, nor will it cease to exist because the user satisfaction survey is not conducted.
3.Dynamic: User satisfaction can be changed by various factors, so the library should do its own work, so that users enjoy high-quality services while maintaining user satisfaction at a high level.
4. Comprehensiveness: User satisfaction includes all aspects of the library, not only one aspect of the library, so the library should be built comprehensively.
5. Implicit: If there is no questionnaire of user satisfaction, user satisfaction will be hidden in users' own subconscious, but it is not hidden in all cases, and it will be revealed when users complain or make some good suggestions.
6. Vagueness: User satisfaction is firstly a vague concept in users' mind, which is intuitive good and evil, and only after that it is filled according to some details above performance. The boundary between satisfied and more satisfied is also blurred in the finally presented user satisfaction[15].
7. Difference: Different needs of users with different knowledge reserves lead to subjective differences in users' evaluation criteria for libraries, and some subjective and objective factors lead to differences in users' satisfaction, and different users of the same project have different feelings and obvious differences.

3 IMPROVED NEURAL NETWORKS FOR DIGITAL LIBRARY SATISFACTION PREDICTION MODEL

3.1 Digital Library Satisfaction Indicators

Digital library satisfaction should select indicators that can reflect the feelings of library users. Using hierarchical analysis and library user satisfaction theory, the digital library satisfaction index system is established from three dimensions: resource effectiveness, service ease of use, and service efficiency, and the constructed digital library satisfaction index system is shown in Table 1. In the digital library satisfaction index system established in Table 1, service ease of use reflects the convenience of digital library services; resource effectiveness reflects the core competence of digital libraries and shows the level of information resources of digital libraries; service efficiency reflects the level of library operation and management[4]. The higher the predicted value of each index in the satisfaction index system, the higher the satisfaction of digital library users. We use the improved neural network prediction model to establish the digital library satisfaction index system and realize the digital library satisfaction prediction.

Reader satisfaction index system of digital library	*Resource effectiveness*	*Resource circulation*
		Resource authority
		Convenience of resource access
		Resource structural integrity

		Resource applicability
		Comprehensive resources
	Service ease of use	*Easy to operate*
		Structural clarity
		Navigation clarity
		Help effectiveness
		Run stability
		Safety in operation
	Service efficiency	*Real-time operation*
		Historical memory
		Feedback effectiveness
		Flow consumption of satisfaction
		Use a sense of achievement
		Use comfort

Table 1: Satisfaction Index System of Digital Library.

3.2 Traditional Neural Network

3.2.1 Principle of BP neural network

BP neural network is a feed-forward error correction artificial neural network, which achieves network training by constantly adjusting the network weights and thresholds between each unit layer. the main operation of BP neural network consists of two processes: forward propagation of signal and backward propagation of error, and the network error can be continuously reduced by constantly adjusting the weights[13].

3.2.2 Establishment of neural network model

In this paper, a neural network structure with one hidden layer is used for analysis. Since the number of input units is 9 and the output units are all 1, the number of units in the hidden layer can be chosen as an integer between 1 and 10 according to the empirical formula, and the relationship between the neurons in the hidden layer and the mean squared error (MSE) curve is obtained by the trial-and-error method. The minimum MSE value is 6 when the number of neurons in the hidden layer is 9, so the number of neurons in the hidden layer is 9[8].

The flowchart of neural network applied in digital library satisfaction prediction is shown in Fig. 1. Neural network applied in digital library satisfaction prediction requires input digital library satisfaction learning samples, pre-processing of the input samples are pre-processed, the samples are transferred to the input layer, the neural network achieves autonomous learning, the learning results are output to the database, and the data in the database is used to achieve the subsequent digital library satisfaction prediction. The data contains historical evaluation data and corresponding weights, and when the neural network predicts the satisfaction of digital libraries, it calls the relevant data in the database to implement multi-angle comparison analysis and obtain the final satisfaction prediction results[5].

The traditional neural network mainly includes input layer, implicit layer and output layer, and the input layer data should have uniform input form to facilitate the neural network to process discrete data. The number of implied layers can be selected according to the actual situation. When the number of implied layers is low, the model has a higher function approximation function and the computational efficiency is improved. The empirical formula for the number of neurons in the hidden layer is as follows.

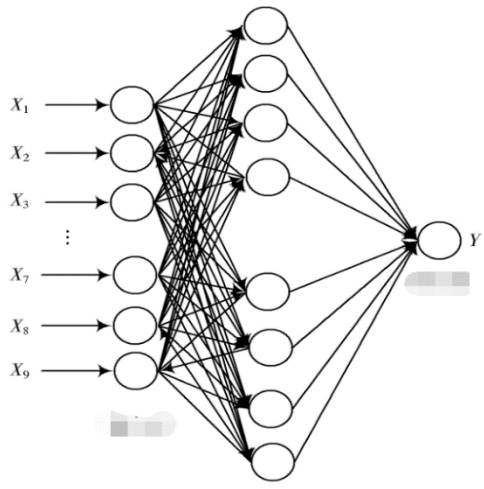

Figure 1: Structure of Computer Network Security Evaluation Based on BP Neural Network Structure.

$$m = \sqrt{n+l} + a$$

Where m and n denote the number of neurons in the hidden layer and the number of neurons in the input layer, respectively, and $l\ and\ a$ denote the number of neurons in the output layer and the empirical value, respectively, and satisfy $1 \le a \le 10$. The final result of satisfaction prediction is taken as the output layer.

3.3 Radial Basis Neural Network

The traditional neural network hidden layer function approach uses the gradient descent method to adjust the weight, which has the defect of easy local convergence and too slow convergence rate. The radial basis function adopts the high-dimensional space interpolation method to adjust the weights, which can effectively improve the convergence performance of the neural network, with strong local approximation ability, superior learning rate and classification ability, and avoid easy
Get into the local optimum situation and improve the convergence rate[21]. When the radial basis function improves the neural network, the relevant data of digital library satisfaction is input into the neural network input layer, and the input layer is sent to the hidden layer. The hidden layer uses the radial basis function to obtain the hidden layer response. Usually, the Gaussian function is selected as the radial basis function, and the Gaussian function is used
The neural network activation function is as follows:

$$R(x_P - c_i) = \exp(-\frac{1}{2\sigma_i^2}\|x_P - c_i\|^2)$$

where $x_p and\ c_i$ denote the p-way input and the center of Gaussian function of the ith node in the hidden layer, respectively, and $2\sigma_i^2\ and \|x_p - c_i\|$ denote the variance of Gaussian function of the ith

node in the hidden layer and the Euclidean norm, respectively and Euclidean parametrization of node i in the hidden layer. The output linear transformation of the radial basis function in the hidden layer is the output layer node of the radial basis network, and the output variable is obtained as follows[25].

$$y_i = \sum_{i=1}^{h} w_{ij} R_i$$

where $j = 1,2,\ldots, n; n \, and \, w_{ij}$ denote the number of output nodes and connection weights, respectively.

4 DIGITAL LIBRARY SATISFACTION PREDICTION MODEL ESTABLISHMENT

4.1 Data Acquisition and Processing

1.Obtain the original data. The original data were obtained by questionnaire, and the digital library satisfaction indexes at all levels were digitized into 1 to 5 points, indicating 5 levels of very poor, poor, medium, good and excellent[27]. The satisfaction prediction results have high fuzziness, and the prediction interval is set as [0, 0.5) for very poor; [0.5, 1.5) for poor; [1.5, 2.5) for medium; [2.5, 3.5) for good; and [3.5, 5] for excellent.
2.Design of the sample. The index values obtained through the questionnaire were set as a sample set and denoted by $Y = f(X_1, X_2, \ldots, X_s)$, where $Y \, and \, X_i$ denote the predicted outcome and the predicted index values, respectively. The sample set is set as training samples and test samples, and the training samples are used to train the radial basis neural network, and the test samples are used to verify the prediction effectiveness of the prediction model. ⊛Data processing. Before inputting the collected data into the radial basis neural network, the collected data should be normalized, and the normalization formula is as follows.

$$x_l = \frac{d_l - d_{l\max}}{d_{l\max} - d_{l\min}}$$

Where x_l denotes the normalized value of the indicator d_l, $d_{l\max} \, and \, d_{l\min}$ denote the maximum and minimum values of the indicator d l, respectively, and the indicator values are converted to the [0, 1] interval according to the normalization process.

4.2 Determining the Network Structure

The number of predicted indicators is set as the input layer nodes, the prediction results are set as the output nodes, the number of categories after the dynamic clustering of training samples is set as the number of nodes in the hidden layer, and only one neuron is needed in the output layer[6].

4.3 Training and Testing

The training process first obtains the learning samples and provides them to the neural network for learning after data preprocessing, and saves the results into the database after the learning is completed for the neural network to use in the evaluation stage[26]. The training samples are dynamically clustered and normalized, and the center of radial basis function of radial basis neural network hidden layer nodes is set as the center of each cluster, and the radial basis function width of each hidden layer node is obtained through the average distance measure between the intra-class sample and the cluster center, with the following formula:

$$\eta_i^2 = \frac{1}{M}\sum_{p=1}^{M}\left(X_p - c_i\right)^T\left(X_p - c_i\right)$$

where $X_p and\ M$ denote the p th sample of the clustered samples and the number of clustered samples, respectively. After fixing the clustering distance and center, the radial basis neural network is trained with the set training samples, and the least squares estimation method is used to obtain the connection weights between the hidden layer and the output layer that minimize the prediction error.The covariance matrix S_{k+1} in Equation is formulated as follows.

$$W_{k+1} = W_k + S_{k+1}a_{k+1}\left(b_{k+1}^T - a_{k+1}^T W_k\right)$$

where S_k and W_k denote the $h \times h$ dimensional covariance matrix and the least squares estimate of W , respectively, and b_{k+1}^T and a_{k+1}^T denote the row vector and column vector, respectively.
The above procedure is used to establish the radial basis neural network digital library satisfaction prediction model, and the test samples are input into the completed training radial basis neural network to obtain the actual library satisfaction prediction values[16],[14].

5 EMPIRICAL ANALYSIS OF LIBRARY EVALUATION

In order to test the effectiveness of the evaluation model, we obtained the scores of 18 evaluation indexes of a library from each service recipient through an online questionnaire, and input them into the trained neural network model to obtain the network evaluation output of each service recipient. Let the evaluation result of the ith service that corresponds to the output of the neural network is $y_i = \left[y_i(1), y_i(2), y_i(3), y_i(4), y_i(5)\right]$, assuming that there are N samples of service users' evaluation, the overall sample belongs to the mean value of excellent, good, medium, average and worse[20],[22].

$$\begin{cases} y_m(1) = \dfrac{1}{N}\sum_{i=1}^{N} y_i(1) & \text{Excellent rating average} \\ y_m(2) = \dfrac{1}{N}\sum_{i=1}^{N} y_i(2) & \text{Good evaluation of the mean value s} \\ y_m(3) = \dfrac{1}{N}\sum_{i=1}^{N} y_i(3) & \text{Moderate evaluation mean} \\ y_m(4) = \dfrac{1}{N}\sum_{i=1}^{N} y_i(4) & \text{The average evaluation mean value} \\ y_m(5) = \dfrac{1}{N}\sum_{i=1}^{N} y_i(5) & \text{The worse evaluation mean value} \end{cases}$$

Here the number of samples obtained from the test N = 150, according to the formula (8) to calculate the final evaluation of the service recipient mean y_m = {0.520, 0.853, 0.420, 0.133, 0.126}, taking the maximum of the five items, the final evaluation should be "good". Another way to deal with this is not to find the average, the output as a conditional probability p , find its product, and then take its maximum value, in order to prevent too many decimal places, the calculation can be taken as a logarithm, that is.

$$p_j = Log\prod_{i=1}^{N} y_i(j)(j = 1,2,3,4,5)$$

Evaluation results $= \max\{p_1, p_2, p_3, p_4, p_5\}$, for the same batch of empirical data, according to the probability distribution p_j ={0.301,0.413,0.115,0.008,0.005} obtained by equation, the evaluation results of the corresponding maximum grade is "good". The above is the comprehensive evaluation results obtained by directly inputting the sample index data into the neural network evaluation model. In the sampling of 150 test samples, 18 index scores were given and the overall evaluation of excellent, good, moderate, fair and poor was given by the service users.

From Table 2, it can be seen that the personalized service of the library with the highest number of "good" ratings is consistent with the predicted results of the neural network model through the index scores, so the model is effective and feasible for the evaluation of service users[23],[2]. In the practical application, the overall evaluation of the service quality can be obtained by inputting only the evaluation scores of the indicators instead of the overall evaluation.

Grade	*Excellent*	*Good*	*Moderate*	*Average*	*Worse*
Quantity	*43*	*50*	*36*	*12*	*9*

Table 2: Evaluation Statistics for Different Grades for the 150 Test Samples.

6 FACTORS AFFECTING USER SATISFACTION AND OPTIMIZATION STRATEGIES

6.1 Factors Influencing User Satisfaction

As mentioned above, satisfaction is the degree to which users' actual feeling of receiving information products and services compares with their prior expectation, and it cannot use the technical indexes of information system itself as the measuring factor of user satisfaction, but should choose the measuring factor from the user's actual feeling of using and judging from the user's demand and expectation. Therefore, there are four main factors affecting user satisfaction:

6.1.1 User's perception of the library

Users' perception of the library can be influenced by various factors. Users can also have certain knowledge about the library through an all-round understanding of the library's rules and regulations, information resources in the collection, bibliographic search system, librarians' competence and quality, and service means and methods[18]. Such knowledge is obtained through reading the introduction of the library, communication with the library staff and other users, and personal experience. The extent of users' understanding of the library depends on the strength of the library's own publicity and user training on the one hand, and on the initiative of users' awareness of the library on the other.

6.1.2 Users' expectations of library use

Users of different qualities have different requirements for library information resources, service methods and librarians' level. General users mainly require more complete books, more reading seats and better service attitude, while researchers require more foreign language specialized books and journals, search tools, convenient search methods and high level librarians who can carry out the service on specific topics.

6.1.3 Users' ability to use the library

The satisfaction of library users depends on their ability to use the library on the basis of their knowledge of the library. The ability to use the library includes not only the ability to collect and retrieve documentary information, but also the ability to read, identify, select and absorb and apply documentary information[19],[10]. A user with rich experience and strong ability to use the library is highly targeted and skilled in using the library, which can reduce some troubles caused by certain links. Conversely, some users may be less motivated to use the library because they are unable to use it properly. A qualified scientist must master not only the relevant professional knowledge and language knowledge, but also the necessary skills of literature and information retrieval and utilization.

6.1.4 Library resources and services

The tangible and intangible factors affecting user satisfaction in this area can be divided into five aspects: (1) Literature resources, whether the scale, capacity and quality of physical and virtual resources meet the needs of users, whether they are convenient to use, and whether the construction of special databases is unique. (2) Web environment, whether the library's webpage can accurately and comprehensively reflect library resources and their functions, the breadth and depth of web navigation, and whether the information retrieval system is well-functioning and easy to operate[17],[9]. (3) Information service, which refers to the attitude of service, the breadth and depth of service, the speed of service, and whether frequent user training services are provided. (4) Information environment, which refers to whether the layout of each functional area of the library is reasonable, whether there is permanent information such as library news, new book bulletin, library rules and regulations, user guide, etc., whether the appearance of the library is clean, neat, quiet and comfortable, whether the sign system of the library is eye-catching and easy to understand, and whether it has the elegant and beautiful artistic atmosphere of the temple of knowledge.

6.2 Measures to Improve User Satisfaction of University Libraries

6.2.1 Pay attention to the survey of satisfaction

Carrying out user satisfaction survey is not only to make an evaluation of library services, but also to derive the difference between the library's knowledge reserves and users' needs, improve the library's knowledge reserves and sound library construction. The user satisfaction survey can also be used to put forward corresponding requirements to the library staff and improve the service quality and work level of the staff. The purpose of opening a library is to provide services to users, so knowing what users think and improving it can promote the work of the library[7],[24].

6.2.2 Strengthening the construction of information resources

Information resource construction has the advantage of fast dissemination and wide range in today's information age. In order to improve service quality and meet users' needs, university libraries are able to satisfy users' demands by asking them to indicate what kind of books they think the library should purchase and what kind of improvements are needed in library staff's work attitude and

services, and try to meet users' demands on the basis of financial support. However, the information age brings both convenience and trouble, and the density of data resources will inevitably cause duplication, which will have a certain impact on user satisfaction collection.

6.2.3 Carrying out user-user e-resource training

The purpose of opening electronic library in university libraries is to serve users so that they can have a better learning environment and learning equipment, and users have a strong learning ability, but in the face of such a relatively unfamiliar system as electronic library, if the staff does not popularize it, it will reduce users' motivation to learn and trigger users' dissatisfaction with their work[28]. Centralized training should be given to the staff so that the staff can correct their learning attitude.

6.2.4 Improving professionalism of librarians

The staff of the library should have the corresponding knowledge and professional quality, and the working outlook of the staff will, to some extent, affect the level of satisfaction of the users with the library, and the most important thing that the users want to receive in the library is one-stop service, which saves their own time and also facilitates access[12]. Therefore, the design of the e-library should be as simple and clear as possible, and all the contents that users need should be summarized on one page. The page setting of the electronic library needs to rely on the professional knowledge of the staff, so the professional knowledge of the staff should be improved so that the staff has high efficiency.

6.2.5 Provide feedback service platform

Feedback service platform is to put forward users' impressions of this library, staff's service attitude and so on, so these feedbacks are relatively important, and by organizing the feedback information, we can have an objective cognition of ourselves, promote the construction of the library, and play a role in promoting user satisfaction. Feedback service platform has a variety of styles, such as the establishment of a suggestion box, weekly or according to the situation to determine the frequency of collection; can also establish e-mail, set up online message board on the page of the electronic library to encourage users to actively feedback[1]. The use of feedback information for their own rectification makes the library become more standardized and institutionalized, and has a good role in promoting the development of the library.

7 CONCLUSION

Under the background of big data, the service contents of libraries are becoming more and more diversified, and the evaluation of user satisfaction is a relatively complicated work, so the different evaluation angles and methods chosen will also affect the final evaluation results. At the same time, with the continuous changes of user satisfaction, digital libraries should also build a perfect evaluation model of reader satisfaction, so as to lay a good foundation for improving service quality. Based on this, this paper proposes a neural network-based reader satisfaction evaluation model for digital libraries. Through empirical analysis, the model helps to analyze the relevant factors affecting reader satisfaction, and puts forward corresponding optimization suggestions.

Shuya Zhang, https://orcid.org/0009-0001-2880-4276
Fei Yao, https://orcid.org/0009-0003-5289-3971

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