

## Research Article

# On the Innovative Work and Development of Library Reader Service in the Era of Artificial Intelligence

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With the continuous development of science and technology, the automated management of libraries has been continuously improved in order to better serve readers and improve the work efficiency of library managers. This paper mainly discusses the innovative path of library automation in the new era of artificial intelligence. Combined with the development of our school's library in recent years, it is discussed to create a new situation of public library service for readers by creating an atmosphere, caring for disadvantaged groups, innovating reader activities, and expanding service content. According to the design idea and implementation process of the ant colony optimization neural network model, we propose a global search strategy—ant colony optimization algorithm—as the learning algorithm of the neural network model for library reader service evaluation.

## 1. Introduction

As the hottest technology in recent years, the impact of artificial intelligence (AI) on library automation has been manifold [1]. For example, artificial intelligence is used in library book retrieval platforms, mainly through relevance ranking algorithms, which are used to obtain the relevance between queries and documents, and further to achieve predictive retrieval and whole document retrieval, which is based on automatic learning of artificial intelligence [2]. In addition to book retrieval, AI is also applied in the process of classifying and arranging books [3]. Big data provides a great help for document classification, book categorization, and document labeling within the library, and after applying big data technology to complete these tasks, the books and documents are then pushed and categorized in a relevant way with the help of artificial intelligence technology [4]. AI technology is also applied in the process of acquiring and subscribing to books in the library, such as the subscription of books, the selection of books and the provision of more accurate and personalized subscription services to individual readers, etc. [5]. The implementation of these functions is inseparable from AI technology. In addition, the use of AI

technology has also enabled the application of robots to organize bookshelves and web chat bots [6].

Although the management of libraries is facilitated by artificial intelligence and other related technologies, the management of books such as the collection still requires a lot of human input [7]. For example, checking and confirming the book collection data in the database, confirming the search number of books, and replacing the wrong book collection location cannot be done without manual work [8]. However, library management in the automated mode still brings a lot of convenience, such as numbering books, modifying book archives, and searching library documents. However, as long as books are checked out, the management has to organize the resources in the library [9]. Therefore, in the process of using the automated management system to manage the library's books, documents, and other resources, the relevant staff should be proficient in using the automated system and using it to issue book lending cards, book barcodes, and other book marks [10]. For example, in the process of managing books in the library, the staff should use the automated system to program barcodes and then print software to create borrowers' library cards [11].

The construction of intelligent libraries requires not only the investment of professional technical personnel but also the support of other resources [12]. The current shortage of artificial intelligence-related talents is also a major reason for the slow R&D process of related technologies, which leads to the slow automation management process of libraries, and thus the lack of fullness in service content. The lack of other resources is also one of the reasons for the slow R&D process [13]. For the development of automation system, the first thing is to collect data, and the lack of data support will lead to the lack of self-learning ability of artificial intelligence, which is precisely the basic function, thus leading to the limitation of user behavior data, making the development of library automation system severely restricted [14]. To avoid such problems, the primary thing is to have a large amount of data support, which requires timely aggregation as well as integration of data information in the library. Only with a database can the data be used for the development and application of library automation [15].

Data mining, which can discover implicit and valuable information through data analysis, has become a hot technology for library patron service evaluation [16]. Especially, neural network with self-learning and self-adaptive ability and good associative memory function is a popular means of data mining methods. [17] is a typical example of library patron service evaluation using BP neural network. From the evaluation process, the determination of evaluation index weights is more objective and reasonable [18]. From the evaluation results, the evaluation is more accurate. Considering that the learning algorithm of BP network is the error back propagation algorithm, which is a nonlinear optimization algorithm based on gradient descent, it has the disadvantages of slow convergence and easy to fall into local optimum [19]. In this paper, the ACO algorithm with strong global search capability is used to improve it. It is demonstrated that the improved ACO neural network model can effectively improve the evaluation accuracy and applicability [20].

## 2. Innovative Development of Library Automation Work in the Era of Artificial Intelligence

Combining artificial intelligence technology with library management methods and striving to realize the construction of smart libraries is a major innovation. The smart library realized with the help of AI technology realizes not only the diversity of user subjects but also the intelligence of library management methods and the wisdom of library push contents. In the smart library developed with AI technology, the service subject of the system is not only the administrator of the library but also the machine with intelligent application, and the system can also provide service for the readers of the library. Secondly, using the data mining technology in artificial intelligence technology, it can also deeply excavate the original knowledge in the library, explore the inner hidden information, and provide the most core and targeted knowledge to the readers. In addition, the intelligent library can also break the original library service

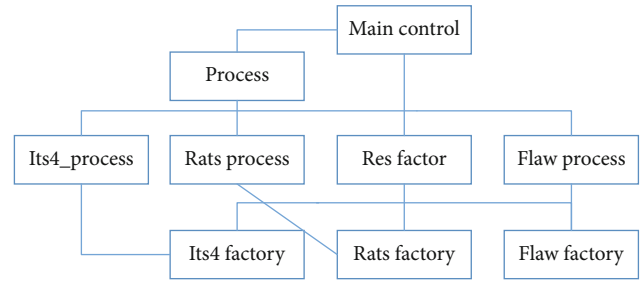


FIGURE 1: Library architecture.

model, readers can access the library knowledge anytime and anywhere through the network, and the library staff can also provide readers with the services they need through online.

With the continuous development of artificial intelligence technology, there will be more functional innovations in robots for library automation management, and more kinds of robots will be created, such as robots for summarizing library knowledge, book retrieval robots, robots for sorting and organizing bookshelves, and robots for customer service on online platforms. It is believed that in the future, library managers and robots can cooperate with each other on the basis of division of labor, as shown in Figure 1, so that they can better serve readers and provide more intelligent and personalized book information to readers. The ultimate goal of the smart library is to provide an intelligent interactive service system to the users, to achieve full coverage of a series of behaviors of readers from entering to leaving the library, and to provide different services according to the preferences and needs of different readers.

## 3. Overview of Ant Colony Optimization Neural Networks

**3.1. Neural Network Meaning.** Neural networks are composed of a large number of neurons interconnected, simulating the way the human brain processes information, with good self-learning, self-adaptive ability, and strong associative memory function, and can effectively complete the high-dimensional nonlinear transformation. BP network is one of the neural network models with a good theoretical basis.

**3.2. Ant Colony Optimization Algorithm.** Ant colony optimization algorithm is a global optimization strategy inspired by the path selection behavior of an ant colony searching for food, which has the advantages of positive feedback, distributed computation, and inspirational convergence compared with general global optimization algorithms such as genetic algorithms. The positive feedback feature helps to find better solutions quickly, the distributed computation feature avoids premature maturation in the iterative process that leads to local optimality, and the initiating convergence feature makes it possible to find acceptable solutions earlier in the search process. The basic process of training neural networks by the ACO algorithm is as follows.

*Step 1.* Initialize the number of ants and the population. Assume that  $m$  represents the number of total parameters in the neural network, including ownership values and thresholds.  $h$  represents the number of ants, and the value of  $h$  is generally close to or slightly higher than  $m$ . For each parameter, it is randomly initialized to  $N$  possible solutions between  $(0, 1)$ , and the set of solutions for the  $i$ -th parameter is set to  $(1 \leq i \leq m)$ ,  $\tau_j(I_{pi})(t)$  denotes the pheromone of the  $j$ -th element  $P_j(I_{pi})$  in the set  $I_{pi}$  at time  $t$ . The initial values of time  $t$  and iteration number  $Nc$  are 0,  $\tau_j(I_{pi})(0) = 0$ , and the maximum number of iterations is  $Nc_{\max}$  with the given accuracy  $\varepsilon$  is required.

*Step 2.* The  $h$  ants are searched for food separately to obtain  $h$  solutions of network parameters, and the network output error of each solution is calculated, where the output error takes the form of mean square error, i.e.,

$$E = \frac{1}{2} \sum_{r=1}^M \sum_{o=1}^L (y_{ro} - d_{ro})^2. \quad (1)$$

The process of searching for food by ants can be regarded as the process of selecting a parameter value from each solution set separately. For the  $k = (k = 1, 2, \dots, h)$  ants, the selection of each parameter value; here, the probability  $P$  calculated according to equation (2) is implemented by the roulette wheel method.

$$P(\tau_j^k(I_{pi})) = \tau_j(I_{pi}) / \sum_{j=1}^N \tau_j(I_{pi}). \quad (2)$$

*Step 3.*  $t' = t + m, Nc' = Nc + 1$ , record the set of network parameters corresponding to the minimum value of the mean square error  $EE_{\min}, E_{\min}$  in  $h$  solutions (i.e., the current optimal solution), and adjust the pheromone for each element in the set of solutions according to equations.

The pheromone is adjusted according to equations (3) and (4) for each element in each solution set.

$$\Delta\tau_j(I_{pi}) = \sum_{k=1}^h \Delta\tau_j^k(I_{pi}), \quad (3)$$

$$\Delta\tau_j(I_{pi}) = \sum_{k=1}^h \Delta\tau_j^k(I_{pi}), \quad (4)$$

where  $\rho$  is the information residual degree and takes a value between  $[0, 1)$ , which can be calculated by equation (5).

$$\Delta\tau_j^k(I_{pi}) = \begin{cases} Q/e^k, & \text{The } k \text{ ant selects the } j \text{ element} \\ 0, & \text{otherwise} \end{cases}, \quad (5)$$

where  $Q$  is a constant used to adjust the adjustment speed of the pheromone, which generally takes a wide range of values and has to be adjusted after several trials to determine.  $e^k$  is

the maximum output error of each training sample when the  $k$  th ant selects a set of solutions as network parameters, which can be calculated from Table (6).

$$e^k = \max_{r=1}^M |Y - D|, \quad (6)$$

where  $Y, D$  are the actual and desired outputs of the network, respectively. If the number of iterations  $Nc < Nc_{\max}$ , and after this iteration  $E_{\min} \leq \varepsilon$ , the iteration ends and the optimal solution is output, i.e., the minimum mean square error  $E_{\min}$  corresponding to the set of network parameters taken. If the number of iterations  $Nc < Nc_{\max}$ , but after this, if the number of iterations  $Nc$  reaches the maximum iteration  $Nc_{\max}$  and  $E_{\min} > \varepsilon$  after this iteration, then step 1 is performed, i.e.,  $N$  possible solutions are reinitialized randomly.

## 4. Establishment of Library Reader Service Evaluation Model

*4.1. Establishment of Evaluation Index System.* There are many factors affecting the satisfaction of patron service. In this paper, based on the comprehensive domestic research, the evaluation index system proposed in the literature [4] is slightly modified to obtain 5 primary indicators and 15 secondary indicators.

### 4.2. Establishment of Evaluation Model

- (1) Questionnaire survey to obtain the original data. The satisfaction scores of readers with each evaluation index were obtained through the distribution of questionnaires and online assessment. Each level of index and target is divided into 5 levels: excellent, good, moderate, acceptable, and poor, and the corresponding numbers are 5, 4, 3, 2, and 1
- (2) Sample design. The indicator values obtained from the questionnaire are used as the sample set, and the sample takes the form of  $Y = f(X_1, X_2, X_3, \dots, X_s)$ , where  $Y$  is the evaluation target and  $X_1 \sim X_s$  is the evaluation indicator.  $f(X)$  denotes the nonlinear relationship between the target and the evaluation index
- (3) Data normalization process. Since the  $s$ -type logarithmic function used for the implicit layer neurons takes values between  $(0, 1)$ , and the evaluation indexes have scores from 1 to 5, the input data must be normalized before the network training. The normalization method is as follows: for the benefit-based indicator with a higher score that is more satisfactory,  $x_l = (X_l - X_{l \min}) / (X_{l \max} - X_{l \min})$ ; for the cost-based indicator with a lower score that is more satisfactory,  $x_l = 1 - (X_l - X_{l \min}) / (X_{l \max} - X_{l \min})$ , where  $x_l$  is the normalized value of the  $l$ -th indicator  $X_l$  and  $X_{l \min}, X_{l \max}$  is the minimum and maximum values of the indicator

As the number of hidden layers increases, the complexity of the BP network structure increases accordingly. According

TABLE 1: Test sample data.

Sample number	$X_1$	$X_2$	$X_3$	$X_4$	$X_5$	$X_6$	$X_7$	$X_8$	$X_9$	$X_{10}$	$X_{11}$	$X_{12}$	$X_{13}$	$X_{14}$	$X_{15}$	$Y$
01	4	3	5	4	3	4	4	5	4	4	4	5	4	3	4	4
02	4	3	3	3	4	3	5	3	3	4	2	3	3	3	4	3
03	3	4	5	4	4	4	3	2	5	4	3	2	5	4	5	4
04	3	4	2	4	5	3	2	4	5	3	3	3	3	4	2	4
05	2	3	3	4	1	3	2	4	3	2	2	3	3	4	4	2
06	3	2	5	1	4	3	2	1	2	3	2	3	3	4	3	3
07	5	4	4	4	4	3	5	4	3	3	3	4	3	3	5	4
08	4	5	5	4	5	4	3	3	4	3	2	4	5	4	3	5
09	4	4	5	5	4	5	4	5	4	5	3	2	4	5	4	4

Note:  $X_1 \sim X_{15}$  are the 15 secondary indicators in Table 1, and  $Y$  is the evaluation target in Table 1.

to Kolmogorov's theory, a 3-layer BP network can approximate any continuous function as long as there are enough hidden nodes. In order to reduce the size of the network and increase the learning speed, a 3-layer network with one hidden layer is chosen here.

The number of nodes in the input layer corresponds to the number of evaluation indicators. Given that the second-level indicators are the basic indicators, they are the basis of the whole evaluation and the fundamental basis for decision-making. In this paper, the number of input nodes is 15 if the secondary evaluation indexes are used as input variables [21–23].

The output node is the evaluation target; therefore, only one neuron is needed for the output layer. Due to the existence of certain ambiguity between the evaluation levels, it is generally considered that the evaluation results of the network output can be within a certain range near the typical values corresponding to the evaluation levels. It is specified as [4]: excellent, [4.5, 5]; good, [3.5, 4.5]; moderate, [2.5, 3.5]; acceptable, [1.5, 2.5]; poor, [0.5, 1.5).

There is no mature theory for determining the number of hidden nodes, which is generally calculated based on the empirical formula and finally obtained by adjusting it through several experiments. The empirical formula used in this paper is

$$s = \sqrt{m + n} + a, a \in (1, 10). \quad (7)$$

The excitation function of each neuron is adopted as the  $s$ -type logarithmic function, i.e.,  $f(x) = 1/e^{-x}$ .

## 5. Case Verification

For example, we divided readers into two groups—teachers and undergraduate students—distributed 30 and 70 questionnaires, respectively, and collected 23 and 66 valid questionnaires, respectively, totaling 89. From the two groups of questionnaires, the first 20 and the first 60, totaling 80, were selected as training samples, and the remaining 9 were used as test samples. The whole evaluation process was implemented by MATLAB7.0 programming. The final BP network with 7 hidden nodes was adjusted according to Equation (5) and several experiments [23–25]. The structure of the BP network is 15-7-1. 80 training samples are stan-

TABLE 2: Comparison of network output with actual values.

Sample number	Estimate		Actual value	Relative error (%)
	Network output	Category		
1	4.0682	Good	4	0.2022
2	3.0611	Medium	1	1.0339
3	4.0008	Good	3	2.5562
4	3.9765	Good	3	0.5781
5	1.9689	Commonly	1	0.5149
6	2.9887	Medium	1	0.7422
7	4.0329	Good	4	1.0677
8	4.9331	Excellent	5	1.5422
9	3.9250	Good	3	1.2659

dardized under the condition that the mean square error  $MSE \leq 0.001$  is required for a given accuracy, and then, the A-CO algorithm is used to train the neural network. The values of the parameters of the ACO algorithm are as follows: the information residual degree  $\rho$  is 0.7, the adjustment speed parameter  $Q$  is 10, the number of ants  $h$  is 100, the number of solutions in the solution set  $N$  is 50, and the maximum number of iterations is 300. After 257 iterations to achieve the accuracy requirement, the network training is finished and the global optimal solution is output. The nine test samples (see Table 1) were normalized and fed into the trained ACON, and the comparison between the network output and the actual value is shown in Table 2.

As can be seen from Table 2, the network output of library patron service evaluation using the ant colony optimization neural network model is completely correct in the aforementioned range of evaluation levels, with good agreement between predicted and actual values and small relative percentage error, the maximum relative error is 2.517 5%, and the root mean square error of the test sample as a whole is only 1.518 8%, which is much smaller than the maximum relative error of 4.631 5% and root mean square error of 2.743 9% using the traditional BP network model. The maximum relative error is 2.517 5%, and the root mean square error of the test sample is only 1.518 8%, which is much smaller than the maximum relative error of 4.631 5% and the root mean square error of 2.743 9%. Although the

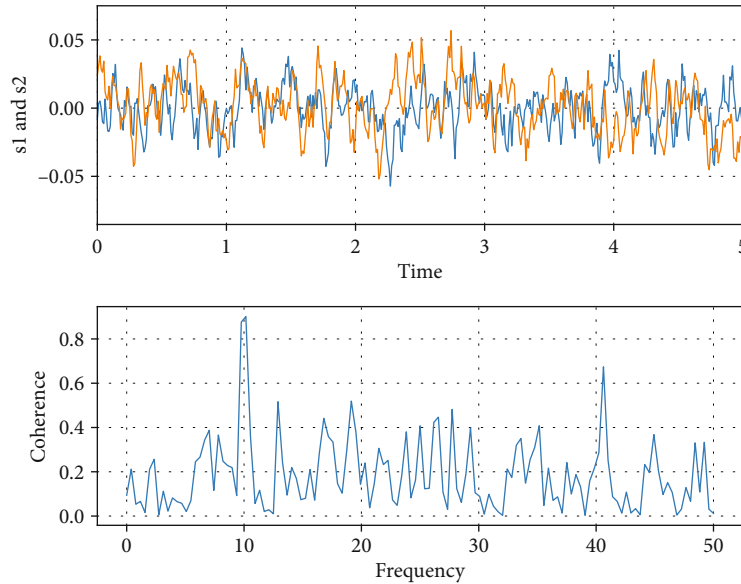


FIGURE 2: Readers' comfort in reading.

running time is slightly longer than that of the traditional BP network model, about 2.5 min, it is still acceptable [26, 27].

As a cultural mecca, library is one of the most important public service places that should have a cultural and artistic atmosphere, but in fact many libraries have empty walls. The Suzhou Library is a model in this regard, with a huge calligraphy banner in the lobby as soon as one enters, giving rise to a sense of admiration for Chinese culture. In addition, the library also has a classical garden-style gallery with inscriptions of famous calligraphers and paintings of Suzhou through the ages, reflecting the general appearance of Suzhou's humanities and cultural prosperity; the airy gallery has inscriptions of the mottoes of the academicians of the two academies of Suzhou, which is a patriotic education base in Jiangsu Province. The environment of the new library of Guangzhou University is also full of artistic atmosphere: bright windows, bamboo shadows, and fragrant ink. Flowers and plants, stone art, root carvings, clay pots, statues, wall decorations, etc. are warm and friendly, and the pleasing art photography and quotations of famous people quietly emit the fragrance of life. Foreign friends exclaim: Here you can appreciate the beauty of traditional Chinese culture and art. The foreign friends praise that they can appreciate the beauty of Chinese traditional culture and art here. Therefore, more and more people like to "soak" here, so that the social education function of the library can be fully played, so that the cultural resources of the library can be fully utilized, so that the advanced knowledge and information can be timely disseminated, see Figure 2.

It can be seen from Figure 2 that the predicted value is in good agreement with the actual value, the relative percentage error is very small, the maximum relative error is 3.517.5%, and the overall root mean square error of the test sample is only 2.418.8%, which is much smaller than the maximum relative error of 4.731.5% and root mean square error of 2.543.9% using the traditional BP network model. The maximum relative error is 2.617 5%, and the root mean square

error of the test sample is only 2.518 8%, which is far less than the maximum relative error of 4.5315% and root mean square error of 3.643 9%. Although the running time is slightly longer than the traditional BP network model, about 2.5 minutes, it is still acceptable.

But in the limited financial conditions, still can "spend less, do more, do good." As long as you are a thoughtful person, you will find a set of warm colors, comfortable and relaxing sofa can also be retained and attracted to readers. Guangzhou City, our new library space environment layout, furniture placement, etc. have been carefully planned and designed, taking into account the cultural needs of readers and physical and mental needs, with humane, cultural, and artistic atmosphere, giving people a quiet, leisurely, relaxed mind enjoyment, full of affinity and attraction. The effect of book sharing is shown in Figure 3. Our university library actively improves the reading environment and creates a warm, comfortable, fresh, natural, and beautiful environmental atmosphere to attract readers to come and read in the library. We have arranged many art scenes in the library and actively carry out daily landscaping work to create a humanized reading atmosphere. The "relaxation" factor is everywhere, and stones and wood, which are taken from nature, are one of the relaxing elements. The new library of our school uses some corners to arrange a lot of green scenery, such as banana, rocks, and bamboo. Some of the leisure tables and chairs are also made of stone. Our library has been hailed by the news media as a "civilian book bar," in large part because of its casual environment, which makes ordinary people feel close, relaxed, and willing to stay there. This approach of our library has been unanimously affirmed by the Ministry of Culture, provincial, municipal, and district leaders at all levels.

In addition, libraries can also add leisure books to help workers relax physically and mentally and return to work in a better condition. Libraries that are in a position to do so can also set up "leisure reading areas." For example, the

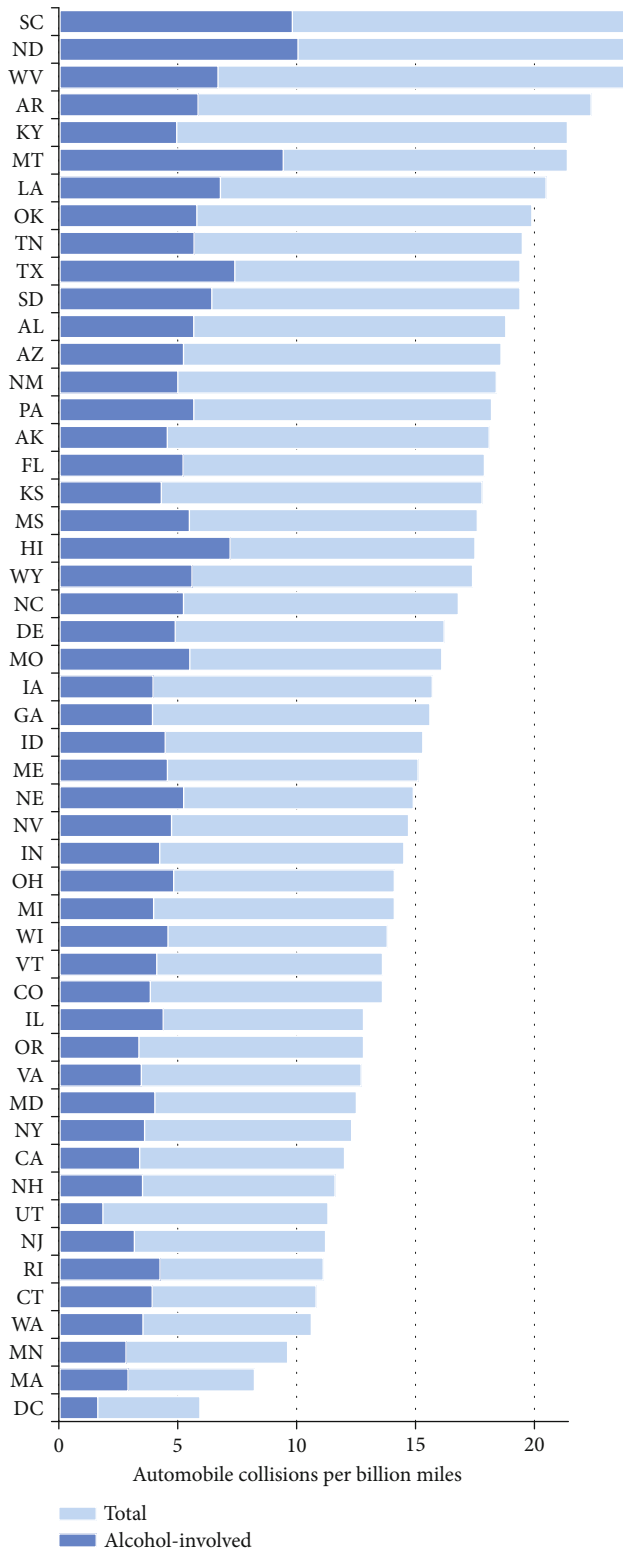


FIGURE 3: Book sharing effect.

new library of Guangzhou University has set up a “leisure reading area” in the lobby on the first floor for readers, where hundreds of popular magazines are placed for readers to read. Another example is the Suzhou Library, which has set up the “Tianxiang Xiaozhu,” a modern garden building

inside the library, as a leisure area for readers, which is widely welcomed by readers. It can be said that the leisure environment is a vivid interpretation of the “humanized” service of public libraries and the implementation of “people-oriented” thinking. It is a vivid interpretation of the “humanization” service of public libraries and the implementation of the “people-oriented” thought.

### 6. Conclusion

This innovative mode of combining artificial intelligence with library management not only greatly improves the efficiency of library staff but also enables readers to have a better service experience and greatly satisfies the needs of readers. Under the wave of the era of artificial intelligence, the emergence and use of smart libraries will definitely bring a big change to the library industry and then realize the informationization and intelligent construction of libraries. The use of neural network evaluation is convenient and objective, and it is easy to achieve dynamic update, which can reflect the change of the influence of each evaluation index on readers’ satisfaction in time. The introduction of the ant colony optimization algorithm makes the determination of the neural network weights more scientific and the evaluation results more accurate. The feasibility and effectiveness of the proposed neural network model are proved by the test of this library.

### Data Availability

The experimental data used to support the findings of this study are available from the corresponding author upon request.

### Conflicts of Interest

The authors declared that they have no conflicts of interest regarding this work.

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