Analysis of Cognitive Factors Affecting Information Retrieval Behavior of University Library Users Based on RBF Network

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Abstract. The information retrieval behavior of library users is affected by many factors. Analysis of these factors will help libraries to formulate high-quality information service strategies. Sample data is obtained by questionnaire survey, and RBF neural network model is used to learn and analyze sample data in this paper. A method for calculating the importance of input components based on RBF neural network is proposed. The influence factors of university library users' information retrieval behavior are studied from a cognitive perspective. The influence results of relevant cognitive factors on information retrieval behavior are discussed. According to these cognitive factors, university libraries can take corresponding information service measures and improve the information retrieval efficiency of library users.

Keywords: Information retrieval behavior · University library · RBF neural network · Cognitive factors

1 Introduction

Information retrieval is a process in which users carry out a series of activities to meet information needs with the help of specific retrieval tools. With the arrival of big data era, information sources are becoming more and more extensive, and information resources are increasing exponentially, which brings difficulties to people in retrieving information. As an information service organization, libraries have a multi-level stable user group. In order to provide users with more reliable information retrieval services, it is necessary for libraries to change the traditional information view, analyze users' information retrieval needs and factors that affect users' information retrieval behavior, so as to formulate a scientific service plan to improve users' information retrieval efficiency and user satisfaction. From the perspective of cognition, RBF neural network model is applied to analyze the cognitive factors that affect the information retrieval behavior of university library users in this paper, so as to provide reference for formulating scientific information retrieval service plans.

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2 RBF Neural Network Model

Radial Basis Function (RBF) neural network [1–5] is a novel feed-forward neural network. Its topology is shown in Fig. 1. It has strong nonlinear mapping ability and can approach a nonlinear function globally with any accuracy. Because there is a complex nonlinear relationship between the cognitive factors affecting information retrieval behavior of university library users and information retrieval satisfaction, it is obviously superior to analyze the cognitive factors affecting information retrieval behavior of university library users by RBF neural network.

The training of RBF neural network usually adopts gradient descent method. The center, width and weight parameters are adjusted to the optimal value by learning. The iterative calculation is as follows:

$$w_{ij}(t) = w_{ij}(t-1) - \eta \frac{\partial E}{\partial w_{ij}(t-1)} + \alpha[w_{ij}(t-1) - w_{ij}(t-2)] \tag{1}$$

$$c_{ij}(t) = c_{ij}(t-1) - \eta \frac{\partial E}{\partial c_{ij}(t-1)} + \alpha[c_{ij}(t-1) - c_{ij}(t-2)] \tag{2}$$

$$d_{ij}(t) = d_{ij}(t-1) - \eta \frac{\partial E}{\partial d_{ij}(t-1)} + \alpha[d_{ij}(t-1) - d_{ij}(t-2)] \tag{3}$$

Where, $w_{ij}(t)$ is the adjustment weight between the k-th output neuron and the j-th hidden layer neuron in the t-th iteration. $c_{ij}(t)$ is the central component of the j hidden layer neuron for the i input neuron in the t iteration calculation. $d_{ij}(t)$ is the with of center $c_{ij}(t)$. η is the learning factor, E is the evaluation function of RBF neural network, whose expression is as follows:

$$E = \frac{1}{2} \sum_{i=1}^{N} \sum_{k=1}^{q} (y_{ik} - o_{ik})^2 \tag{4}$$

We take the cognitive factors affecting users' information retrieval behavior as the input vector of RBF neural network, and the satisfaction of information retrieval as the output vector. Cognitive factors include cognitive style, cognitive ability, knowledge and

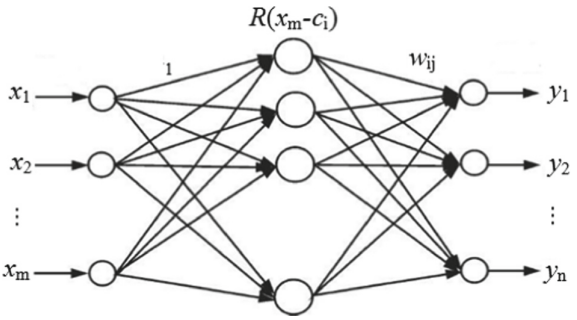

Fig. 1. Topology of RBF neural network [Drawn by authors]

experience, and emotional status; Knowledge experience includes knowledge structure, social experience and retrieval experience. Input vectors X = {xi}, i = 1, 2,…, 9, and x1, x2,… x9 represent cognitive style, thinking ability, expression ability, imagination, memory ability, knowledge structure, social experience, retrieval experience, and emotional status respectively. The output vector Y = {y}, y represents information retrieval satisfaction. According to the principle of differential calculus, the trained RBF network is used to calculate the impact on the output results when each component of the input vector has a small change, so as to evaluate the importance of the input dimension to the output results. We introduce the concept of importance to measure the importance of each component of the input vector to the output results. The definition of importance is as follows:

Definition: Let the input mode vector of RBF neural network be $X_k = (x_1, x_2, \cdots, x_m)$, $k = 1, 2, \cdots, p$, where p is the number of input modes, m is the dimension of the input mode vector, and the corresponding output mode vector of the input mode is $Y_k = (y_1, y_2, \cdots, y_n)$, where n is the dimension of the output mode vector. Y_i is the output Y when the i-th component of input mode has a slight change Δx_i. The following formula is the importance of x_i to Y.

$$I_i = \frac{\partial Y}{\partial x_i} = \lim_{\Delta x_i \to 0} \frac{\Delta Y}{\Delta x_i} \approx \frac{\|Y_i - Y\|}{\Delta x_i} \tag{5}$$

In this way, according to the importance of each input component to the output, the importance of each input component to the output result can be analyzed. If there are some components in the input vector, they have little impact on the output result, that is, their importance is very low. Such components are unimportant components.

3 Analyzing the Cognitive Factors Affecting the Information Retrieval Behavior of University Library Users by RBF Neural Network

3.1 Questionnaire Investigation

In order to obtain the training samples of RBF neural network, we designed a questionnaire "Investigation on Cognitive Factors Affecting the Information Retrieval Behavior of University Library Users", and conducted a sampling questionnaire survey on the students of Hunan Institute of Science and Technology. The survey included personal questionnaires on cognitive style, cognitive ability, knowledge and experience, and emotional status, as well as a self-assessment form on the impact of these factors on their information retrieval behavior. There are 600 students surveyed, including 356 male users and 244 female users, accounting for 59.38% and 40.62% respectively. There are 364 undergraduate users, 115 postgraduate users and 121 teacher users. The proportion of undergraduate, postgraduate and teacher users is 60.63%, 19.21% and 20.16% respectively.

3.2 Training and Analysis of RBF Neural Network

We selected 280 samples from the survey data set as training samples, and the remaining samples can be used as test samples. Some training samples are shown in Table 1. We firstly use training samples to train RBF neural network, and then the trained network is used to calculate the importance values of each input component. Table 2 shows the results of 6 experiments, in which each row data are the importance values of each input dimension when each increment is taken.

It can be seen from the results in Table 2 that the 5th dimension (memory ability) and 7th dimension (social experience) components are the minimum values in each experiment. It can be seen that they are unimportant components and have little impact on the output. Therefore, we believe that the satisfaction of information retrieval behavior of university library users is not related to memory ability and social experience, but is significantly related to cognitive style, thinking ability, expression ability, imagination, knowledge structure, retrieval experience and emotional status.

Table 1. Some data in the training sample set

No.	x1	x2	x3	x4	x5	x6	x7	x8	x9	y
1	1.0	8.0	7.0	8.0	9.0	8.0	8.5	8.0	1.0	8.5
2	2.0	7.0	8.0	7.5	8.5	7.0	8.0	9.0	1.0	9.0
3	1.0	7.0	6.0	6.5	8.0	6.5	7.0	7.0	3.0	6.5
4	2.0	6.0	7.5	7.0	8.0	6.0	7.5	7.0	1.0	7.0
5	1.0	6.5	6.0	6.0	7.5	7.0	6.0	6.0	2.0	5.5
6	2.0	5.0	5.5	5.0	7.0	5.5	6.5	6.5	1.0	6.0
7	1.0	5.5	5.0	4.0	6.0	4.5	5.0	4.5	1.0	5.5
8	2.0	5.0	4.5	4.0	6.0	4.5	5.0	4.0	2.0	5.0

Table 2. Importance values of input components

Δx_i	x1	x2	x3	x4	x5	x6	x7	x8	x9
0.1	6.4255	6.3065	6.3065	6.3065	6.0215	6.3065	6.0215	6.5120	6.3872
0.2	5.8620	5.7725	5.7725	5.7725	5.4610	5.7725	5.4610	5.9326	5.8010
0.3	4.8527	4.7028	4.7028	4.7028	4.6516	4.7028	4.6516	4.9676	4.7655
0.4	4.4825	4.2696	4.2696	4.2696	4.0843	4.2696	4.0843	4.5022	4.3361
0.5	3.6552	3.5274	3.5274	3.5274	3.4190	3.5274	3.4190	3.7729	3.5853
0.6	3.3075	3.1129	3.1129	3.1129	3.0520	3.1129	3.0520	3.3552	3.1896

4 Discussion of Cognitive Factors Affecting Information Retrieval Behavior of University Library Users

Cognitive style [6] includes field dependence and field independence. Field independent users prefer to complete retrieval tasks independently according to their own wishes and ideas. They are less affected by the external environment. Field dependent users are more dependent on the external environment, and they prefer to use the system structure and prompts when retrieving information.

The cognitive ability [7] affecting users' information retrieval behavior mainly includes thinking ability, expression ability and imagination ability. With different thinking abilities, users will have different understanding of problems in the process of information retrieval, which will affect users' choice of information sources, retrieval methods and retrieval strategies, evaluation of retrieval results, and acquisition and utilization of information. The ability of logical expression determines whether users can express their real information needs with accurate words in the retrieval process, and whether they can formulate retrieval expressions that meet the retrieval requirements. The more imaginative the users are, the easier they will accept the system interfaces with different design styles and find the information they need, so their retrieval efficiency will be high.

User's knowledge structure and information retrieval experience [7–10] are crucial to information retrieval. Users with professional domain knowledge can propose more reasonable retrieval topics, master retrieval skills faster, and construct more logical retrieval expressions. Search knowledge can help users use more reasonable search methods and search strategies to achieve satisfactory search results. Comprehensive knowledge related to retrieval system functions can help users master various functions and operating mechanisms of retrieval systems, thus improving the success rate of information retrieval. Compared with users without retrieval experience, in the information retrieval process, users with retrieval experience choose more targeted keywords when constructing expressions, they can develop more logical retrieval strategies, and can more flexibly deal with various problems in the retrieval process. Their retrieval efficiency is higher than those without retrieval experience.

In the process of information retrieval, users' emotional status has an important impact on users' information retrieval behavior. Positive emotional conditions promote their retrieval behavior, while negative emotional conditions hinder their retrieval behavior. In the process of interaction between users and retrieval systems, positive emotions and negative emotions have frequently occurred with the cognitive activities of information retrieval results. On the premise of clear information needs, users can shorten the time to complete their retrieval tasks by being positive and confident, which is conducive to the smooth progress of their information retrieval process and improves the retrieval efficiency.

5 Conclusion

Cognitive factors such as cognitive style, thinking ability, expression ability, imagination, knowledge structure, retrieval experience and emotional status have great influence on the information retrieval behavior of university library users. In order to improve users'

information retrieval skills and efficiency, university libraries should carry out relevant information literacy training. The training content mainly includes: (1) Humanistic literacy and information value education, which purpose is to improve users' cognitive ability and enable users to maintain correct information awareness and positive emotional status. (2) The training of information resources and information retrieval technology, which purpose is to enable users to have a reasonable information retrieval knowledge structure and improve their information retrieval skills. Users can make more use of library information resources by training, thus the utilization rate of information resources is improved. And the university library information resources can serve teaching and scientific research better.

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