

Design and Implementation of an Electronic Journal Resource Recommendation System Integrating User Profile and Knowledge Graph

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Abstract: In order to facilitate users to find the literature they need in a massive number of electronic journals, this article designs and implements a recommendation system based on the fusion of user profile and knowledge graph recommendation model. The system extracts feature from users downloaded electronic journal resources, and combines the knowledge graph of electronic journal resources to construct a recommendation model that effectively alleviates the problem of data sparsity and enhances the recommendation effect. System testing shows that the system has implemented the functions of each module and can provide personalized recommendations to users.

Keywords: Knowledge Graph; User Portrait; Personalized Recommendation; Electronic Journals.

1. Introduction

There are massive resources in the library, and there are currently two solutions for mining valuable information from large-scale data to alleviate the problem of "information overload": information retrieval technology and information filtering technology. The application of information retrieval technology in search engines is very popular, and people can quickly retrieve the resources they need through search keywords. However, one drawback is that search relies too much on keywords. If users have a clear and explicit understanding of their needs, they can quickly obtain corresponding resources. However, sometimes users are not clear about their needs, which makes it difficult to conduct searches and results are always unsatisfactory. At this time, the information filtering technology represented by personalized recommendation technology has gained widespread attention in the industry. By analyzing users' historical behavior data, potential points of interest are discovered, and relevant resources are actively recommended. Sometimes the recommendation results are more in line with the actual needs of users than what they search for themselves. Currently, personalized recommendation technology has developed rapidly and is widely used in movie websites and shopping platforms. Personalized recommendation based on electronic resources can recommend different resources for different users, which not only reduces the time for users to search and consult, but also fully utilizes the resources of the library, reducing the underutilization of resources caused by insufficient search.

Traditional personalized recommendation algorithms mainly include item-based recommendation, user-based recommendation, and hybrid recommendation algorithms. Among them, personalized behavior recommendation algorithms have attracted the attention and research of industry experts for their superior behavior analysis and interest modeling techniques. For example, Netflix and YouTube in foreign countries, Tiktok and Taobao in China can use mature user portrait technology to achieve better personalized recommendation. After 2015, with the development of big data technology and artificial intelligence,

research on personalized recommendation in the field of image and situational awareness began to integrate artificial intelligence technologies such as knowledge graphs and situational awareness. For example, Liu Haiou et al. analyzed user information by integrating situational awareness, combined with collaborative filtering algorithms, to construct a contextualized library resource recommendation system [1]; Shao Bilin and Yang studied the development of personalized resource recommendation in libraries in the field of knowledge graphs [2]. It can be seen that the research on library resource recommendation in China, the exploration of smart libraries, the development of new technologies such as artificial intelligence, and the deepening of personalized service concepts are inseparable.

The user profile of libraries in our country has not been thoroughly studied. Most research is still in the theoretical stage, mainly focusing on model design, method exploration, and application mode exploration. There are few or ineffective cases of applying user profiles to library construction practice. One of the reasons for this is the lack of funding, technology, and talent. The second is the lack of ideology and insufficient policy support. Through literature analysis, it can be found that scholars studying library user profiles have too loose connections between libraries and research institutions, with almost zero connections between each other, and are basically in a state of independent research [3]. This leads to a separation between research and practice, and the results of research cannot be well applied and developed in practice, resulting in a lack of development in the study of library user profiles and the establishment of a complete research system. The research results of scholars lack feedback and evaluation mechanisms, which leads to a separation between research and actual needs. Overall, research on book systems in China started relatively late, and the vast majority of online library services have not yet achieved personalized recommendations for specific users. This study aims to address the problem of poor practicality in the field of personalized recommendation in libraries, and to design and develop an electronic journal resource recommendation system that integrates user profiles and knowledge graphs, in order to promote the transformation and

upgrading of library services.

2. System Overall Design

2.1. Model Fundamentals and Key Technologies

2.1.1. Knowledge Graph

Due to the large scale of Internet content, heterogeneous diversity, loose organizational structure and other characteristics, it challenges people's effective access to information and knowledge. The resource recommendation service based on knowledge graph improves information utilization and user satisfaction by intelligently screening and filtering massive information resources, and analyzing user information needs in real-time based on user profiles and information retrieval behaviors [4]. Essentially, a knowledge graph is a semantic network that reveals the relationships between entities, allowing for formal descriptions of real-world objects and their interrelationships [5].

This study adopts steps such as data collection, knowledge extraction, and knowledge fusion to construct an electronic journal resource knowledge graph, and uses visualization functions to view the knowledge graph, as follows:

(1) Data collection

It is necessary to collect behavior data on users downloading journals, including user IP, journal titles, source databases, downloaded page numbers, page ranges, download types, file names, and download times; Collect user information, including user name and IP address; Collect journal information, including author, title, literature source, year, volume, issue, page number, ISSN, keywords, institution, abstract, image classification number, article number/DOI number, and citation; Collect citation information, including citation titles and authors.

(2) Knowledge Extraction

Analyze the collected data, identify, filter, and summarize the information, and extract knowledge units containing three major elements: relationships, entities, and attributes. For structured data, simple rules can be directly applied from relational databases to form part of a knowledge graph; For unstructured data such as text data, it can be converted into structured data or extracted based on learning. For the research content of this study, it is necessary to extract knowledge such as citation data, relevant author data, and user download data from library literature resources. Finally, four structured data tables including periodic, citation, user, and download were obtained and imported into the database.

(3) Knowledge Storage

Using the Neo4j graph database to store knowledge graphs enables efficient data insertion and querying, and provides algorithm tools and query languages for graphs. Neo4j is a graph database belonging to the NoSQL database, but it is not used for front-end display of data, but for storing data. Its principle is to use graph theory in mathematics to store data and its relationships in nodes and edges, rather than storing data and its relationships in database table fields like traditional databases. It requires the use of some front-end display tools for front-end display.

(4) Visualization

Visualize the Neo4j database using D3.js, a JavaScript library that uses dynamic graphics for data visualization. The specific implementation operations include: bolding the connections related to nodes when clicked with the mouse, dragging with the left mouse button, fixing nodes, left clicking on blank spaces, dragging the canvas, zooming in and out of the canvas with the mouse wheel, displaying the entire screen when clicked, searching for node information based on keywords, exporting images, and downloading relationship data.

2.1.2. User Portrait

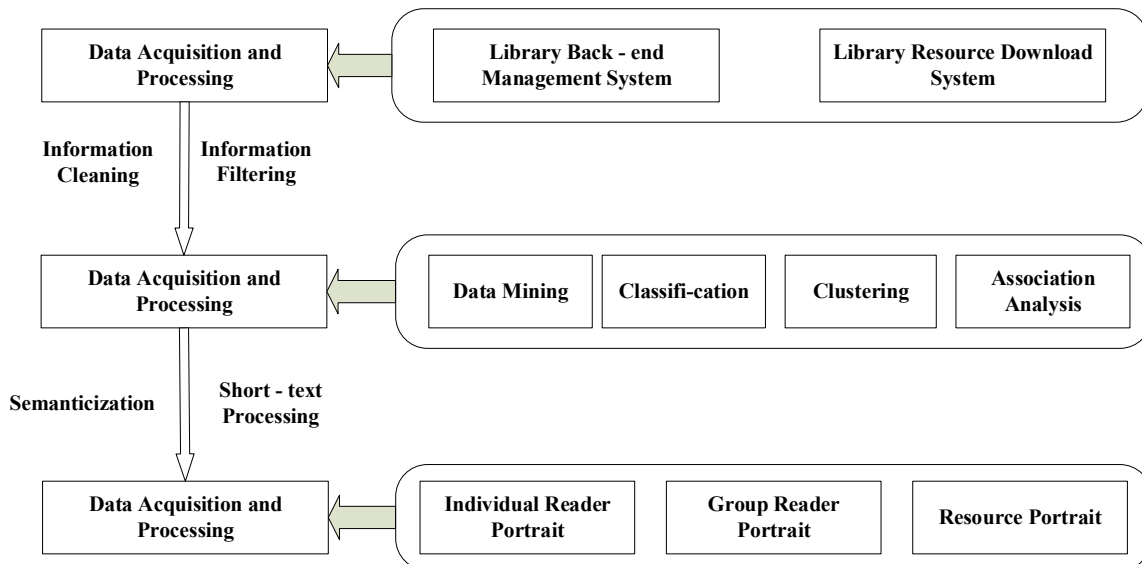


Fig 1. User portrait construction

The purpose of user profiling is to truly reflect user characteristics and transform them into data that can be understood by computers, serving as the basis for upper-level application practices. The construction of portraits mainly includes two aspects: manual extraction and automatic extraction, and manual acquisition often leads to incomplete models [6]. By combining basic information with behavioral information, the visualization of user profiles can be better

served [7]. Regarding the analysis of existing user profiling models, the acquisition of user data generally starts from four dimensions: natural attributes, user preference attributes, interaction behavior attributes, and social behavior attributes. Correspondingly, it is necessary to collect user identity information, interaction behavior data, etc.

Building accurate user profiles requires tagging and vectorizing user data to provide computable numerical

information for subsequent data analysis. The labeling system cannot be established arbitrarily. It must be based on scenarios that meet user needs and establish a reasonable, complete, and scalable labeling system, otherwise it will have an impact on the performance of the model. This study constructs a tagging system for user profiles based on the journal data downloaded by users and user characteristic information.

The user profile model needs to describe the characteristics of the reader, which is constructed from three levels: data source layer, data analysis and processing layer, and data label layer, as shown in Figure 1.

2.1.3. Recommendation Algorithm

This study adopts a hybrid recommendation algorithm based on user profiling and knowledge graph for electronic journal resource recommendation. The implementation process is as follows [8]:

(1) Build a user similarity matrix. Calculate the similarity between users based on different calculation methods, and

finally obtain the final user similarity matrix by adjusting the weights.

(2) Use knowledge graph to derive project neighborhoods. Based on the knowledge graph, generate a triplet of entities, relationships, and entities, and obtain a set of neighboring user IDs based on the triplet information.

(3) Convolutional aggregation. Initialize all users and projects. For the user vector, we select the top user volume to accumulate the final user representation. For the project vector, we aggregate $h \times k$ neighbor vectors through h strips in the neighborhood to form the final project vector.

(4) Calculate the recommended results. Calculate the inner product of the user vector and item vector obtained above to obtain the final recommendation result.

2.2. Overall Architecture Design

The overall architecture of this system is divided into data layer, application support layer, business logic layer, and presentation layer, as shown in Figure 2.

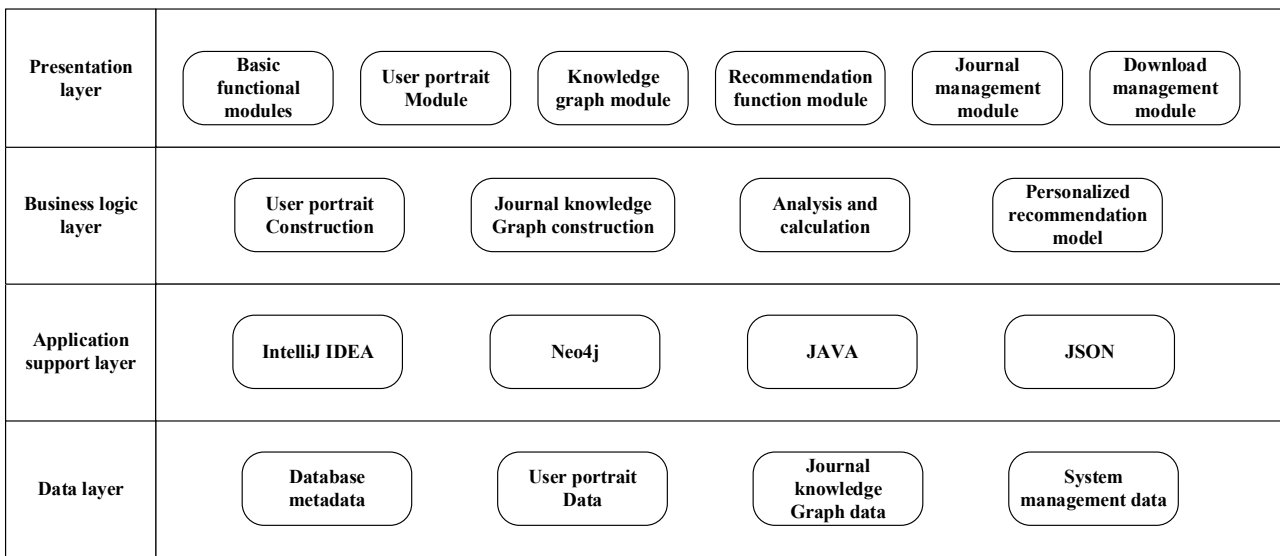


Fig 2. System Architecture

2.2.1. Data Layer

The data layer is the fundamental support for implementing system functions, mainly including user profile data, knowledge graph data, metadata, and system management data. The data layer has storage, backup, and other functions, providing data support for the application of system functions.

2.2.2. Application Support Layer

The application support layer is the development environment, programming language, database, etc. that support the system. The development language of this system is Java, and the front-end language mainly uses JavaScript and Vue. It relies on the IDEA development platform for front-end and back-end code writing and testing. The graphic design uses Photoshop CS5 software, and the Git repository provides project code management functionality. The development mode adopts a front-end and back-end separation development based on Vue and Spring Boot, separating the project business of the front-end and back-end to achieve better decoupling. The front-end adopts the progressive Vue.js framework to build the user interface. This framework only focuses on handling page interactions and underlying logical relationships. The corresponding Element UI and Echarts development components of the Vue.js framework provide better data visualization and display

effects, solving the problems of data communication, DOM manipulation, and data rendering in conventional web development. The backend uses the currently stable and popular open-source web project frameworks Spring Boot and My Batis, where My Batis is paired with My SQL database to build a persistence layer framework and relies on Redis for intermediate data caching. Overall, users have a better interface experience.

2.2.3. Business Logic Layer

The business logic layer is the core support of the system. After the presentation layer submits relevant operations, they are processed through the business logic layer and finally return the operation results.

2.2.4. Presentation Layer

The presentation layer is the interface for computer user interaction, providing system web functions, data exchange programs, or data interfaces to display data, receive input data, and provide feedback on business logic layer data for users [9]. This layer is directly aimed at user usage, where users send requests for basic functional modules, reader management modules, journal management modules, download management modules, recommendation modules, knowledge graph modules, user profiling modules, and other functions in the system to the business logic layer. Design the

UI interface through a control library and implement business logic through UI components to achieve the functionality of the presentation layer.

3. System Functional Design

The system is divided into login management module,

system management module, reader management module, journal management module, download management module, recommendation module, knowledge graph module, and user profile module, as shown in Figure 3.

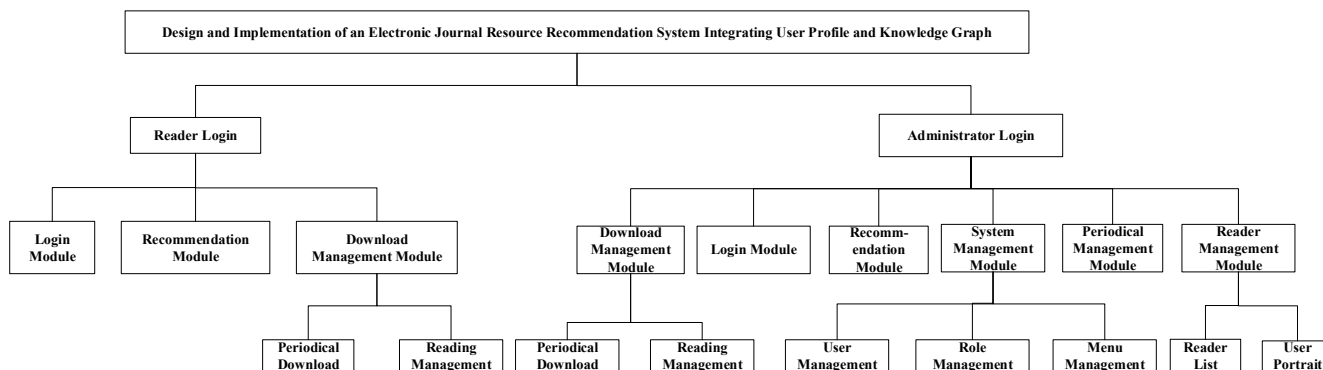


Fig 3. System functions

3.1. Login Module

responsible for verifying the user's identity information to enter the corresponding page and user registration. Administrators and readers have different functional requirements.

3.2. System Management Module

responsible for user management, including searching, adding, editing, deleting, and resetting passwords for user information; Role management, including editing, deleting, and assigning permissions to roles; Menu management, including adding, editing, and deleting menu lists.

3.3. Reader Management Module

it is responsible for managing the data related to readers, searching the reader information according to student number, name, telephone number and ID number, and adding, editing and reviewing the reader information.

3.4. Journal Management Module

Responsible for displaying journals and their related information, and can search for journals based on their names, sources, and authors, as well as add, edit, and delete journals.

3.5. Download Management Module

The administrator needs to first query the reader information and then download the journal. They can search for the journal based on its name or author and then download it. After entering the view management, they can query the corresponding reader's journal download information through their student ID, and then read and delete the downloaded journal; Readers do not need to search for reader information, they can directly search for journals and download them. After entering the view management, they can view all the downloaded journal data and view specific download information for reading and deletion based on the journal name.

3.6. Recommendation Module

Using a user based collaborative filtering algorithm to recommend journals and related citation journals that other users like and have similar interests to the user.

3.7. Knowledge Graph Module

The main function of this module is to mine and process electronic journal information, and construct a journal knowledge graph. The knowledge graph module is the knowledge support of the intelligent library information recommendation service, responsible for matching suitable knowledge resources. It can be said that this module is the knowledge data guarantee for the quality of the intelligent library information recommendation service.

3.8. User Profile Module

The main function of the User Profile Module is to mine, collect, analyze, and integrate user data, extract tags that reflect user characteristics, and construct user profiles. The user profile module is the user side support for intelligent library information recommendation services, responsible for providing real and effective user needs. It can be said that this module is the demand data guarantee for the quality of intelligent library information recommendation services.

4. Summary

In order to meet the personalized recommendation needs of library readers for electronic journal literature, this article designs and implements an electronic journal resource recommendation system that integrates user profiles and knowledge graphs. Although the various functions of the system have been completed, the management of system users, roles, readers, journals, and user download behavior has been achieved; Implemented interest profiling of users based on their download behavior. When users perform download operations, their interest table will change accordingly. At this time, the recommendation algorithm will recalculate the user and display new recommendation results; Implemented the construction of a knowledge graph based on users, download behavior, downloaded journals, cited journals, and their relationships; Personalized recommendation of journal resources has been achieved. But there are also the following issues:

(1) The updating and improvement of the knowledge graph requires manual implementation by the administrator, and further improvement is needed to achieve automatic updating

and improvement;

(2) The portrait tags of the user portrait module are not yet complete.

(3) When reading a journal, formatting issues may cause the journal to not open properly, and such issues need to be resolved in the future.

(4) The system interface only has data and buttons, which is relatively simple. In the future, the interface can be designed to improve the user experience.

(5) There are relatively few operations on the reader side, which can only be used for downloading, reading, and other operations. In the future, we can continue to improve the user side operations, such as adding journal comment and collection functions, as well as adding functions for readers to share literature and discuss issues with each other.

In the future, we will continue to improve the system and make it play its due role.

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