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A Novel recipes recommendation system Based on Knowledge-Graph

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***Abstract*—With the improvement of living standards, the demand for personalized recipes is getting more and more attention. Therefore, this paper designs and implements a beneficial recipe recommendation system based on dietary knowledge mapping. The front-end of the system uses Vue.js to build the user interface, and the back-end uses Spring MVC framework to implement. And the recommendation technology based on the knowledge graph is studied, and the recipe recommendation method is improved by using knowledge graph. Firstly, we crawled recipe knowledge through crawlers and built a dietary knowledge graph integrating multi-domain information by using the rich semantics of knowledge graph. Secondly, the knowledge graph is combined with the collaborative filtering algorithm implemented by Mahout to improve the effectiveness of recommendations. Finally, an intelligent Q&A module is developed for the system based on the knowledge graph to provide accurate and effective recipes for people and patients with dietary choice difficulties.**

Keywords-knowledge graph; recommendation system; beneficial recipe recommendation; system design

I. INTRODUCTION

With the continuous improvement of material living standards, a balanced diet has been widely concerned. However, there are few studies on recipe recommendation systems[1], and it is difficult for people to filter recipe information from the Internet to meet their individual needs. And the traditional recipe recommendation system does not combine the actual needs of users to make recommendations, and the achieved effect is rather ordinary.

Collaborative filtering algorithms are widely used in the field of personalized recommendation [2] and have achieved good results [3], however, sub-based recommendation algorithms face problems such as cold start, computational complexity, and sparse data, which become bottlenecks of collaborative filtering methods [4]. To solve these problems, researchers have improved collaborative filtering by introducing external information [5]. Among the many external information, the knowledge graph, as a knowledge base developed from the semantic web, has a large number of descriptions of domain entities and relationships between entities and rich semantic information [6].

In recent years, knowledge graphs have become one of the main knowledge sources for tasks such as semantic search and knowledge quizzes, and have achieved good results in these fields. Therefore, research on using knowledge graphs to improve the performance of recommender systems is gradually gaining attention. As an emerging information carrier, it contains many types of entities and semantic relationships between entities. Thus, introducing knowledge graphs into personalized recommendation alleviates the cold-start problem of traditional recommendation algorithms, discovers potential correlations between recommended items, and improves the accuracy and diversity of recommendations [7]. In addition, knowledge graph embeds entities and relationships into a low-dimensional dense vector space to improve the efficiency of computation. Therefore, it is necessary to combine knowledge graph with personalized recommendation.

II. CONSTRUCTION OF A DIETARY KNOWLEDGE GRAPH

The diet-based knowledge graph consists of a triad of entities and relations, such as <hypertension, desirable ingredients, celery>. The establishment of the diet-disease knowledge graph in this paper consists of the following steps: Firstly, crawling the graph data source using crawler technology. Data extraction is performed on semi-structured and unstructured information [8]. The acquired data is parsed into a DOM [9] tree. Subsequently, entity identification was performed from the extracted semi-structured text, and a total of eight types of entity nodes were created for diagnostic test items, medical departments, diseases, drugs, food, and symptoms, with the number of entities reaching 44,000 magnitudes.

After the identification of entities, the relationships between entities are then defined. As shown in Table 1, a total of 10 types of relationship types are established in this paper. The mapping relationship between recipe information and ingredient information, the connection between ingredient information and dish information, the contraindication and benefit relationship between dish and disease, and the correspondence relationship between disease information and treatment drug information are constructed respectively. Based on the target raw data and the knowledge graph, the target dish information matching the target user is obtained, and the dietary recommendation information is provided to the target user. Finally, a Neo4j graph database [10] is used for knowledge storage.

TABLE I. KNOWLEDGE GRAPH ENTITY-RELATIONSHIP TABLE

Entity-relationship type	Number of relationships
belongs_to	8,844
common_drug	14,649

do_eat	22,238
drugs_of	17,315
need_check	39,422
no_eat	22,247
recommand_drug	59,467
recommand_eat	40,221
has_symptom	5,998
acompany_with	12,029

III. Recommendation Algorithm Implementation

The focus of the user-based collaborative filtering algorithm [11] is on user groups. The algorithm first searches for groups with the same characteristics as the user, and by analyzing the user data among the groups, it speculates on the matching degree with the current user, and finally selects the one with a higher matching degree and pushes it to the user. The higher the proportion of similar items among users to the total items, the higher the similarity between the two, and the higher the possibility of recommendation.

In this paper, we fuse the knowledge graph and the user-based collaborative filtering algorithm implemented by Mahout [12]. Using the Top-k method, the k most similar users in front are selected, and the recipes with the greatest repetition are recommended from among the k users. Recipes recommended in this way are more accurate. After obtaining enough user rating samples for the recipes, the rating prediction can be made for the target user dishes, and the rating prediction formula is shown in equation (1)

$$Pv_{i,s} = \bar{R}_i + \frac{\sum_{j\in UC} Rec_{i,j}(\bar{R}_{jw,s} - \bar{R}_j)}{\sum_{j\in UC} Rec_{i,j}} \tag{1}$$

$\bar{R}_i$ and $\bar{R}_j$ are the mean values of different users' ratings for their respective recipes. $Rec_{i,j}$ denotes the accuracy of the recipe recommendations. UC denotes the last recommendation result set. $\bar{R}_{jw,s}$ denotes the mean value of users' ratings for recipe S. Finally, the predicted value of the user's rating of the recipe, $Pv_{i,s}$ is calculated. A user-recipe rating matrix is generated in the recipe recommendation system, which records the details of all users' ratings for all items, and is shown in equation (2)

$$\begin{array}{cc} & \begin{array}{ccc} I_1 & \cdots & I_n \end{array} \\ \begin{array}{c} U_1 \\ \vdots \\ U_m \end{array} & \begin{pmatrix} R_{11} & \cdots & R_{1n} \\ \vdots & \ddots & \vdots \\ R_{m1} & \cdots & R_{mn} \end{pmatrix} \end{array} \tag{2}$$

The user matrix is derived from the user's preference level of recipes by the collaborative filtering algorithm implemented in Mahout, and the user's preferences are inferred based on the preferences of the nearest neighbors. The results are fused with the knowledge graph, and a two-dimensional matrix is built in more dimensions using the existing inter-entity correlations to enhance the accuracy of the recommendations. Finally, optimized recommendation results are passed to the recipe recommendation system for display. The overall architecture of the recommendation algorithm is shown in Figure 1.

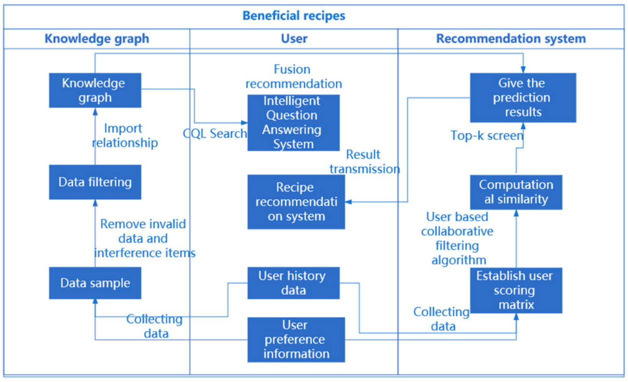

Figure 1 Recipe recommendation algorithm architecture

The recommendation process in this paper is shown in Figure 2. Firstly, the similarity between recipes is obtained through the knowledge graph, which is combined with the user's preferences for recipes derived from collaborative filtering to recommend recipe items that may be of interest to users. The similarity between recipes is calculated according to the knowledge graph to get the knowledge graph similarity matrix, and then the similarity matrix is calculated according to the user preference matrix, and finally, the two results are fused according to a certain fusion ratio as the final recommendation result

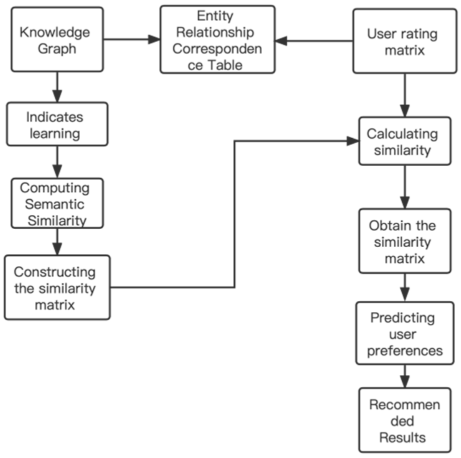

Figure 2 Recipe Recommendation Process

IV. General System Architecture

A front- and back-end separation [13] development model was chosen for the beneficial recipe recommendation system based on the knowledge graph. The front-end uses Vue.js to build the user interface using the Element UI library for fast layout and construction of the page. The local data refresh and the encapsulation of AJAX [14] are implemented using Axios. The back-end technology is implemented using the Spring MVC framework. servlet receives user requests and responds to the results, calls other components for processing, controls the global flow and reduces the coupling between other components. The role of HandlerMapping is to find the corresponding Controller based on the URL of the request, thus invoking the specific business logic and implementing the relevant functionality. Using the B/S [15] architecture, the server-side is used to process user requirements, and the recommendation algorithm based on the knowledge graph is used to calculate and make the corresponding recipe recommendations; it consists of three parts: data persistence, web service, and recommendation algorithm.

The overall architecture of the system is shown in Figure 3. The client layer provides user front-end and administrator back-end for users and administrators respectively. The display support layer uses HTML + CSS + JS to provide system display. The request support layer is responsible for request interaction between the front and back ends. The business service layer consists of the functions provided by the system. It provides a series of functions around recipes for users. It provides the administrator with functions such as recipe management, recipe review, and user management. The data support layer provides the underlying data support application for the system, stores the classified recipe data, and submits the recipe information to the recipe management of the representation layer, etc.

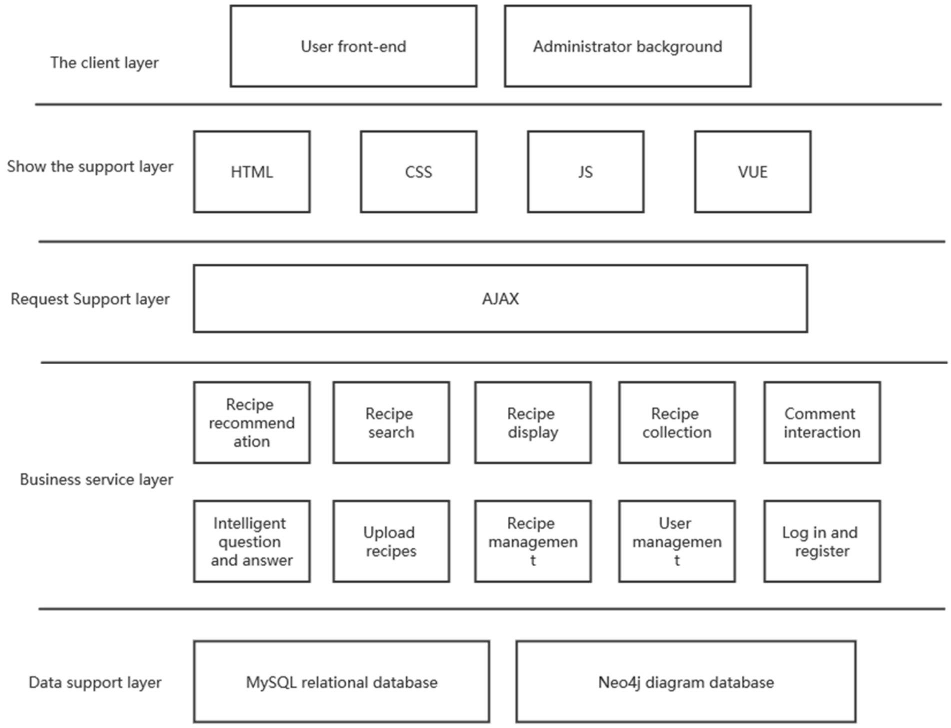

Figure 3 General system architecture diagram

A. *Functional module design*

User registration module: users can register as members and fill in their health status to build a basic user profile, laying the foundation for the intelligent health recipe recommendation function. Recipe recommendation module: After the user logs in, the back-end retrieves the user's health data according to the user ID and uses the recommendation algorithm to recommend recipes that are beneficial to the user's health based on the graph database. Intelligent Q&A module: After the user initiates a question, the system retrieves the data in the graph database based on the user's question, combines the answer and gives feedback to the user. Recipe details module: users can view the detailed recipes, providing recipe pictures, videos, recipes, ingredients, nutritional value references and other functions. According to the user's health condition, the ratio of ingredients in the ingredient list can be adjusted, or the user can be reminded not to eat such dishes to ensure the user's health. Recipe search module: provides users with the ability to search for recipes by keywords, ingredients, labels, cooking time and other aspects.

V. System Implementation

In order to display more output information and enhance the user experience. The overall front-end of the system is designed in a dynamic and simple style. The front-end interface is shown in Figure 4, with a bright yellow design and a simple message. The navigation bar lists the commonly used functions of the system, making it easy for users to jump around quickly. A rotating image is set up on the home page to promote the advantages of the website. The recipes are displayed in a card style with a responsive layout. All the buttons are rounded and use a yellow color scheme, echoing the main color scheme of the website. A separate module is set up on the home page to promote the features of the system, intelligent recipe recommendations, health quizzes and other special features to facilitate users' understanding of the system.

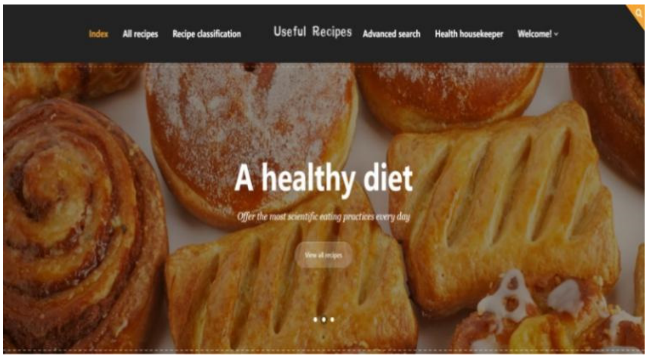

Figure 4 Main system interface diagram

The intelligent Q&A system developed in this paper is shown in Figure 5. When the user enters a question for recipe recommendation consultation, the system first performs natural language processing on the user's question, segments the question, analyses the question type and identifies the named entity. From there, the identified keywords and entity types are matched in the knowledge graph to find the corresponding recommended recipes, which automatically and efficiently completes the accurate recommendation of the recipes required by the user.

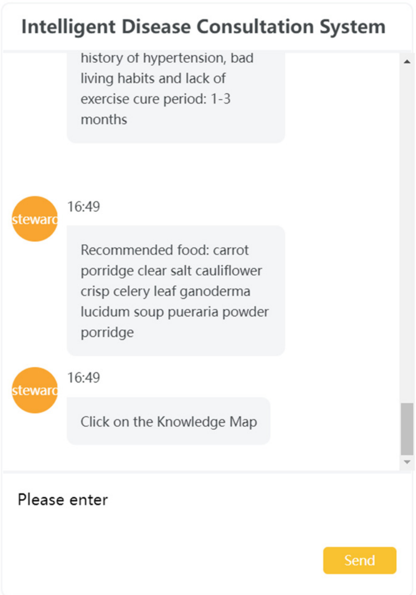

Figure 5 Intelligent Quiz Module

VI. Conclusion

To solve the problem of recommending beneficial recipes, this paper designs and implements a beneficial recipe recommendation system based on the diet-knowledge graph. First, a diet-disease knowledge graph is constructed by crawling recipes and disease-related data from the Internet. The recommendation technique based on the diet-knowledge map is studied, and information such as the association between diseases and recommended recipes established on the knowledge map, symptom and disease associations are fused to build a two-dimensional matrix so that the recommendation algorithm of the intelligent question and answer module in the system can be implemented. Finally, the design and implementation of each module in the system were carried out using the method of front and back-end separation. A beneficial recipe recommendation system with good human-computer interaction capability is developed to meet the needs of users.

Although the beneficial recipe recommendation system implemented in this paper has a good recommendation effect, it can be optimized and improved in the following aspects: To facilitate the use and operation of users, the development of a beneficial recipe APP can be considered in the future, and the recommendation algorithm in this paper is currently focused on textual information analysis but does not incorporate multimodal information such as pictures and videos into the recommendation system. The data can be extended to combine multimodal data with the recommendation system.

The data in the system is still limited, and in order to improve the recommendation quality of the system, the expansion of the knowledge graph is indispensable, and more disease diet information should be added to meet the recommendation needs of different people.

References

[1] Zhong Liangliang. Design and implementation of a recipe recommendation system based on dietary knowledge graph [D]. Southeast University,2019. DOI:10.27014/d.cnki.gdnau.2019.003171.

[2] Goldberg D , Nichols D A , Oki B M , et al. Using collaborative filtering to weave an information TAPESTRY[J]. Communications of the ACM, 1992, 35(12):61-70.

[3] Koren Y , Bell R , Volinsky C . Matrix Factorization Techniques for Recommender Systems[J]. Computer, 2009, 42(8):30-37.

[4] Malik S , Bansal M . Recommendation System: Techniques and Issues. 2019.

[5] Wang H , Zhang F , Hou M , et al. SHINE: Signed Heterogeneous Information Network Embedding for Sentiment Link Prediction[J]. 2017.

[6] Chik Guilin, Gao Huan, Wu Tianxing. Advances in knowledge graph research[J]. Intelligence Engineering, 2017, 3(1):22.

[7] Wang H , Zhang F , Wang J , et al. RippleNet: Propagating User Preferences on the Knowledge Graph for Recommender Systems[J]. ACM, 2018.

[8] Yuan Q, Shi YINJUN, Liu JUNXiang, Yu GUITO, Chen BIND. A method for constructing kitchen diet knowledge graph [C]//. Proceedings of the 2020 China Household Appliance Technology Conference. [publisher unknown],2020:1385-1390.DOI:10.26914/c.cnkihy.2020.032544.

[9] Chen Feifei. Research and application of DOM4J-based XML document parsing technology[J]. Software Guide,2016,15(03):36-37.

[10] Duan Chunxi. Research on recipe recommendation by fusing knowledge graph and collaborative filtering [D]. North Central University,2021. doi:10.27470/d.cnki.ghbgc.2021.000821.

[11] Zhao W.T.,Zhang Shuo. Collaborative filtering algorithm based on user preferences under sparse data[J]. Journal of Chongqing University of Posts and Telecommunications (Natural Science Edition),2021,33(04):669-674.

[12] Ou Weihong,Yang Yongqin. Research on Mahout-based book recommendation system under big data platform[J]. Computers and Telecommunications,2021(09):28-31. DOI:10.15966/j.cnki.dnydx.2021.09.007.

[13] Wu Changzheng. Design of web development framework based on front and back-end separation technology[D]. Nanjing University of Posts and Telecommunications, 2020. doi:10.27251/d.cnki.gnjdc.2020.000727.

[14] Zang, Jinmei. AJAX-based asynchronous processing of epidemic JSON data query[J]. Information Technology and Informatization,2021(05):120-122.

[15] Luo W. Design of primate data information system based on BS model[J]. Enterprise Science and Technology and Development,2018(08):74-76+78.