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Original Research Article

Design of personalized nutritional meal recommendation system driven by big data

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Abstract: In the context of the continuous development of big data technology, personalized nutritional meal recommendation systems have become an important means for people to their eating habits and enhance their quality of life. The purpose of this study is to design a personalized nutritional meal recommendation system based on big data analysis to meet users healthy eating needs. The system collects and analyzes data on users' dietary preferences, health status, and lifestyle habits to build user profiles. It then combines a food database with a nutritional needs calculation model, using improved content-based recommendation algorithms: collaborative filtering algorithm and hybrid recommendation algorithm, to provide users with personalized nutritional meal recommendations The system design is user-centered, aiming for precise recommendations and using technical means to promote healthy eating habits among the general public.

Keywords: Big data analytics; Personalized nutrition meals; User profiling; Nutrition model; Recommendation algorithm

1. Introduction

In the context of modern fast-paced life, healthy eating is increasingly valued. However, how to formulate a reasonable dietary plan based on nutritional needs and dietary preferences is a challenging issue. Traditional nutritional meal recommendations are often not personalized enough and find it difficult to meet the specific requirements of different users. the context of the continuous advancement of big data technology, the design of a personalized nutritional meal recommendation system driven by big data analysis has become a reality

2. Demand analysis of personalized nutrition meal recommendation system driven by big data analysis

2.1. User requirements

As the living of people continue to improve, health has become a focus of attention for more people. In modern society, individuals' requirements for food are no longer limited to taste satiety, but they place more emphasis on nutritional balance and health management. Especially in a rapidly changing social environment, many people, due to being busy with and having a fast pace of life, cannot reasonably arrange their diets, leading to weight gain, nutritional imbalance, or long-term health problems. Therefore, a personalized meal recommendation system has emerged, which meets people's demands for dietary diversification. Users expect that through this system, they can recommend the most suitable meal plans on personal health conditions, health goals, and dietary preferences to improve nutritional structure, prevent diseases, and even improve their physical condition.

2.2. Business requirements

In the commercial context, the personalized nutritional meal recommendation system is both a technical tool and a business platform with potential. How to utilize big data to accurately meet users' personalized needs in the catering industry, especially in the field of healthy catering, has become a key point enhance corporate competitiveness. By using data-driven personalized recommendations, catering merchants can provide customers with tailor-made catering plans based on their health data and historical consumption records, thereby customer loyalty and stickiness. This customized service can not only improve the customer's dining experience but also effectively increase the added value of catering products and form a differentiated advantage.

3. Design of a personalized nutritional meal recommendation system driven by big data analysis

3.1. Overall design

A. Data Layer Design

The data layer is at the core of the personalized nutritional meal recommendation system, responsible for the acquisition, storage, and management massive amounts of user and food data. Firstly, the system needs to collect users' health information through various channels, mainly including weight, blood pressure, blood sugar and dietary habits. To ensure the comprehensiveness of the data, the system also needs to connect with smart wearable devices, health monitoring tools, and mobile applications obtain users' physiological data in real-time. Secondly, the food data layer requires the construction of a massive food database to record the nutritional components, calorie content, parts, and ingredient combinations of each food. These data need to be kept updated in real-time to reflect changes in market ingredients and suggest seasonal foods. Thirdly the system requires an efficient storage mechanism to ensure real-time querying and processing of data for a large number of users.

B. Algorithm Layer Design

In the personalized meal recommendation system, the algorithm layer acts as the "brain" of the entire system, responsible for analyzing large amounts of data and generating personalized recommendation results. To accurate recommendations, the system needs to use various algorithms for recommendations, including content-based recommendation algorithms, collaborative filtering algorithms, and deep learning methods. For example,-based recommendation algorithms analyze the nutritional components and taste preferences of foods, and combine users' health goals to recommend suitable meal plans; collaborative filtering algorithms recommend the same or foods to similar users by analyzing the similarity of user behaviors, which is applicable for new users; deep learning algorithms can further explore users' potential needs and health goals generate more personalized and accurate recommendations. Additionally, the algorithm layer needs to have self-adaptive capabilities and dynamically adjust according to user feedback. After users provide feedback on meal plans, the system should adjust its recommendation strategy based on the feedback results to improve the accuracy of recommendations and user satisfaction

C.Application Layer Design

The application layer, serving as the frontend for user-system interaction, is mainly responsible for displaying recommendation results facilitating user interaction. The design of the application layer needs to balance smooth user experience, clean interface, and complete functionality. During the design process, efforts should be

to ensure humanization and personalization, allowing users to customize their meal plans based on their health goals, dietary preferences, forbidden foods, and other information. Meanwhile the system should be able to update user health data in real-time and make dynamic adjustments. For instance, users can view recommended recipes on their mobile applications, analyze nutritional components of the dishes, and match them with their current health goals. Additionally, users can record their mood during meals through nutritional feedback, which helps the system optimize its recommendations. Furthermore, the application layer should provide health data tracking and meal plan adjustment suggestions to assist users in achieving long-term health management goals

3.2. User profile construction

A. User Data Feature Extraction

The accuracy of the personalized nutrition recommendation system on the establishment of user profiles, which in turn depends on the in-depth mining of user data. Feature extraction from user data is the first step in building a profile. This system collects multi-dimensional data such as personal basic information, health status, and living habits to fully understand user needs. The basic information includes age,, height, and weight; health status includes body fat rate, blood sugar, blood pressure, and medical history; and living habits include dietary preferences, exercise volume and sleep patterns. This data helps the system accurately assess the user's health status and dietary needs, and then provides personalized recommendations. For example, a system might the user's basal metabolic rate based on their age, weight, and height, and then infer the user's caloric needs. For users with special needs, as diabetics, the system can adjust the meal recommendations based on the user's blood sugar levels. Additionally, for users with high exercise volumes, the system increase the protein intake to ensure their body recovery.

B. User Tagging System Establishment

By extracting features from user data, a user tagging system is constructed to accurately 细分用户群体 and enhance recommendation effects. The tagging system can be divided into dimensions such as dietary preferences, health goals, and lifestyle. For example, users be tagged as "vegetarians," "low-fat dieters," or "low-sugar dieters" based on their dietary preferences; based on health goals, can be categorized as "weight loss users," "muscle gain users," or "health maintenance users"; and based on lifestyle, they can be further divided intosedentary users" and "high-activity users." Through tagging, the system can better understand the needs of different types of users and provide more accurate recommendations For instance, for weight loss users, the system might suggest low-calorie, high-fiber meal plans, while for muscle gain users, it might suggest hightein, high-energy meal plans.

3.3. Establishment of nutritional models

A. Construction of Food Nutritional Component Database

The food component database contains detailed nutritional information of various ingredients. To ensure the accuracy and scientific nature of the recommendations, the system needs to record the nutritional components of each food detail, covering calories, proteins, fats, carbohydrates, vitamins, minerals, and other dimensions of data. To build this database, we should combine the current research in nutrition and refer to authoritative nutritional databases, such as the USDA's food database, while considering the dietary habits and food characteristics of our own country to enhance the of food data. In the construction of the database, the system should fully consider the diversity and seasonality of foods. For example, the nutritional components of some may vary in different

seasons, and the database needs to be updated and adjusted in time to maintain the timeliness and accuracy of the information. Additionally, the cooking of food also affects its nutritional components, such as steaming, boiling, frying, and other cooking methods which have different effects on the nutrients in the food.

B. Calculation Model Based on Nutritional Needs

A calculation model is established based on nutritional needs, which combines user health data to calculate the nutrients needed by the user day, and then recommends the most suitable meal plan according to these nutrients. The calculation model needs to be customized according to the user's personal characteristics and health goals For example, someone who wants to lose weight may have a lower calorie requirement, while someone who wants to gain muscle may need to increase protein intake. However, certain specific users, such as diabetics, they may need to limit sugar intake. When designing the model, it is necessary to consider the user's basal rate (BMR), activity level, and health goals for precise calculations. BMR refers to the energy consumed by a person at rest, which can generally be from the user's age, gender, height, and weight. Using BMR-based calculations, we can determine an appropriate total daily energy expenditure (TDEE for the user. Additionally, the system needs to calculate the requirements for macronutrients (e.g., proteins, fats, carbohydrates) and micronutrientslike vitamins and minerals) to ensure that the recommended meal plan meets the user's comprehensive nutritional needs.

3.4. Personalized recommendation algorithm design

A. Improvement of Content-Based Recommendation Algorithm

In nutrition recommendation systems, content-based recommendation algorithms are commonly used. These algorithms suggest items similar to those a user has shown interest in, based on their past behaviors and. In the context of dietary recommendations, the content-based recommendation algorithm proposed in this article can recommend similar foods to users based on the nutritional components, taste, and methods of the food. To enhance the accuracy of the recommendations, improvements can be made to the content-based recommendation algorithm. For instance, more nutritional data can be into the recommendation calculations to better meet users' actual nutritional needs. For users looking to reduce their calorie intake, the system can include recommendations for low-calorie high-fiber foods; for users needing to increase their protein intake, foods rich in protein can be added. Additionally, recommendations can be refined by considering users' goals and food pairing rules. For example, some food combinations can enhance nutrient absorption efficiency, while others might cancel each other out.

B. Application of Collaborative Algorithm in Nutritional Recommendations

Collaborative filtering algorithms make recommendations based on the analysis of similarities between users, using the preferences of similar users to make suggestions. the context of nutritional meal recommendations, collaborative filtering algorithms analyze users' historical meal orders, preferences, and feedback to identify groups of users with similar dietary habits and health. Recommendations are then made based on these similar user groups. Unlike content-based recommendation algorithms, collaborative filtering does not require prior knowledge of specific food characteristics; it can recommendations using only user behavior data. This gives collaborative filtering an advantage in handling large user groups, as it can leverage collective wisdom to recommend potentially preferred meals to users By utilizing user ratings, meal selection history, and other information, the system can uncover potential meal preferences and offer users meals they haven't tried but

might be interested.

C. Integration and Optimization of Hybrid Recommendation Algorithms

Hybrid recommendation algorithms combine various recommendation methods with the aim of leveraging the strengths of each to provide more suggestions. In a personalized nutrition recommendation system, a hybrid recommendation algorithm can integrate content-based recommendations, collaborative filtering, and other methods (such as recommendations based on deep) to provide users with recommendations from multiple perspectives. Hybrid recommendations offer several advantages, such as being able to compensate for the weaknesses of a single algorithm. For example a content-based recommendation algorithm might struggle with the "cold start" problem for new users, but collaborative filtering can solve this by using the behavior of the user group The hybrid algorithm can dynamically adjust and continuously optimize the recommendation results based on user feedback. In practice, the design of a hybrid recommendation algorithm needs to be tailored to scenarios and user needs to ensure high-quality recommendations under various conditions.

4. Implementation and testing of the personalized nutrition meal recommendation system driven by big data analysis

4.1. Development environment and technology selection

The development of the personalized nutrition meal recommendation system requires the use of modern technology stacks to ensure the processing of massive amounts of data and provide quick and accurate recommendations. The system should be built on efficient data processing frameworks like Hadoop and Spark to support big data analysis and real-time processing. The programming languages are Python and Java, with the former chosen for its powerful data processing libraries and the latter suitable for backend and complex algorithms. Frontend development can frameworks like React or Vue.js to provide a better user experience. For the database, MySQL or PostgreSQL can store user and menu data, while MongoDB is suitable for nutrition and user behavior data. The system must comply with data protection regulations and implement encryption and permission controls to protect user privacy.

4.2. Implementation of system functional modules

The personalized nutrition meal recommendation system includes several key modules. The user management module handles user registration, login, information updates, and health data entry, creating a health for the user and providing a custom meal plan. The recommendation engine module, at the core of the system, uses recommendation algorithms to analyze user needs and generate personalized plans. The recommendation results include food details, nutritional analysis, and reasons for the recommendation. The feedback module allows users to evaluate the recommendation results, and based on, the system optimizes its recommendation strategy. The data analysis module analyzes user behavior data and optimizes the recommendation algorithm to aid in marketing decisions.

4.3. System

Comprehensive testing is required to ensure the stability and reliability of the personalized nutrition meal recommendation system. This includes testing of functionality, performance, user experience, and. Functionality testing checks if the modules operate correctly, performance testing evaluates the response and concurrency

capabilities in big data, user experience testing focuses on the accuracy of interface design and recommendations, and security testing ensures the safety of sensitive data. Integrated testing helps detect and fix issues, enhancing system stability and user satisfaction

5. Conclusion

In summary, the personalized nutritional meal recommendation system designed in this article can provide users with more accurate and personalized dietary to improve eating habits and enhance the quality of life. During the design process, user needs and business needs were fully considered, and by building user profiles, constructing models, and designing recommendation algorithms, the system aims to accurately understand user dietary preferences and scientifically calculate nutritional needs. In the future development process, with the in-depth of big data analysis technology and the continuous accumulation of user data, this system is expected to further improve recommendation accuracy and personalization, thereby providing stronger technical support for healthy eating.

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