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Research on Personalized Recommendation System of E-Commerce Based on Big Data

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Abstract: *This paper studies the personalized recommendation system of e-commerce based on big data, focusing on its key technologies and application scenarios in data collection, user portrait construction and recommendation algorithm optimization. By analyzing the role of big data in recommendation system, combined with the core technologies such as collaborative filtering and content filtering, this paper expounds how to provide consumers with more accurate and personalized product recommendation. In addition, the article also discusses the effects and advantages of the system in practical applications such as commodity recommendation and advertisement push through case analysis, and looks forward to the future development trends and challenges.*

Keywords: *big data; E-commerce; Personalized recommendation system; User portrait; Optimization of recommendation algorithm; Application scenario*

1. Introduction

With the popularity of Internet and mobile devices, e-commerce has become an indispensable part of modern life, providing consumers with unprecedented shopping convenience. However, with the explosive growth of the types and quantity of goods on e-commerce platforms, users are often confused when faced with massive information, and it is difficult to find goods that meet their needs quickly. This problem not only affects the shopping experience of users, but also restricts the further development of e-commerce platform[1].

In order to solve this problem, an e-commerce personalized recommendation system based on big data came into being. The system uses big data technology to deeply mine and analyze user behavior, commodity information and transaction data, and provides personalized and customized commodity recommendation services for users by constructing user portraits and accurate recommendation algorithms. This can not only improve the shopping efficiency and satisfaction of users, but also help the e-commerce platform to improve sales and user loyalty[2].

This paper aims to deeply study the theoretical basis, key technologies, application scenarios and future development trends of e-commerce personalized recommendation system based on big data. First of all, this paper will introduce the application value and significance of big data in recommendation system; Secondly, the core technologies such as user portrait construction and recommendation algorithm optimization will be elaborated in detail. Then, through case analysis, it shows the effect of the system in practical applications such as commodity recommendation and advertisement push. Finally, the challenges and future development direction of the system will be discussed in order to provide useful reference for the research and practice in related fields[3-4].

Through the research of this paper, we expect to have a deeper understanding of the operating mechanism and advantages of e-commerce personalized recommendation system based on big data, and make contributions to the further development and innovation in this field. At the same time, we also hope that the research results of this paper can provide strong support and help for e-commerce enterprises in the fierce market competition and help them achieve sustainable development.

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2. Big data and personalized recommendation system

2.1 The concept and value of big data

Big data refers to large-scale and complex data sets that are difficult to process in traditional data processing applications. They include structured data (such as tables in databases), semi-structured data (such as XML documents), and unstructured data (such as text, images, and videos). In the e-commerce environment, big data covers user browsing history, purchase record, click stream, search query, social media interaction, device use information, etc[5].

The value of big data lies in its ability to provide data-driven insights for decision-making. By analyzing these data, enterprises can find hidden patterns, trends and correlations, and then better understand user needs, predict market changes and optimize business processes.

2.2 The importance of personalized recommendation system

Personalized recommendation system is a technology that uses user data and machine learning technology to predict user interests and recommend related content. In e-commerce, personalized recommendation system plays a particularly important role. It can select products that users may be interested in from a large number of products according to their shopping habits, hobbies, geographical location and other information, and improve their shopping experience[6].

Personalized recommendation system can not only increase users' satisfaction and loyalty, but also improve the sales and profitability of e-commerce platform. Through accurate recommendation, e-commerce platform can recommend long-tail goods to interested users, realize diversified sales of goods and improve inventory turnover rate[7].

2.3 The combination of big data and personalized recommendation system

The combination of big data and personalized recommendation system is a natural fit. Big data provides rich user behavior data and commodity information, which provides a solid foundation for personalized recommendation system. Personalized recommendation system can make full use of these data, predict users' interests and behaviors through algorithm model, and realize accurate product recommendation[8].

This combination is not only reflected in the accuracy and efficiency of recommendation algorithm, but also in the diversity and novelty of recommendation. Personalized recommendation system based on big data can analyze users' long-term and short-term interests, discover users' potential needs, recommend novel and interesting products for users, and stimulate users' desire to buy.

2.4 Big Data and Personalized Recommendation System

The combination of big data and personalized recommendation system is one of the important trends of e-commerce development. It can help e-commerce platform better understand users' needs, provide accurate product recommendation services, and improve users' shopping experience and platform profitability. With the continuous progress of technology and the continuous accumulation of data, personalized recommendation system based on big data will play a greater role in the future[8].

3. Research on personalized recommendation system of e-commerce based on big data

3.1 Data Acquisition and Pretreatment

When building an e-commerce personalized recommendation system based on big data, the first problem to be solved is data collection. This includes collecting user behavior data, commodity information and transaction data from e-commerce platform. User behavior data can include users' browsing records, search records, purchase records, evaluation records, etc. These data can reflect users' interests and needs. Commodity information includes commodity name, category, price, description, pictures, etc. These data are helpful to systematically understand the characteristics and attributes of commodities. Transaction data includes order information, payment information, etc., which can reflect the sales situation of the market and the purchasing power of users[10].

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The collected original data often have problems such as noise, missing values and abnormal values, so it needs to be preprocessed before it can be used in subsequent recommendation algorithms. Pretreatment steps include data cleaning, de-duplication, filling in missing values, normalization, etc. The purpose of data cleaning is to remove invalid data and noise data and ensure the accuracy and reliability of data. De-duplication is to avoid the influence of duplicate data on recommendation results. Filling missing values is to deal with the missing problem in data, and methods such as mean filling and mode filling can be used. Normalization is to map data to a unified scale and eliminate dimensional differences between different features.

3.2 User Portrait Construction and Update

User portrait is the core of personalized recommendation system based on big data. It is an abstract description of users' needs based on multi-dimensional information such as users' basic information, behavior data and interest preferences. By constructing user portraits, the system can understand users' needs and preferences more accurately and provide personalized product recommendations for users.

The construction of user profiles requires comprehensive consideration of both static attributes and dynamic behaviors. Static attributes include the user's age, gender, occupation, geographic location and other basic information, which can be obtained through user registration or third-party login authorization. Dynamic behavior includes the user's browsing records, purchase records, search records, etc. These behavioral data can reflect the user's interest and demand changes.

In order to maintain the accuracy and timeliness of user profiles, the system needs to update user profiles periodically. The methods of updating user profiles include incremental updating and full updating. Incremental updating is to make local adjustments based on the new behavioral data of users on the basis of the original user profile. Full update is to recalculate all the user's behavioral data to generate a new user profile. In practical applications, the appropriate update method can be selected according to the frequency of data update and the performance requirements of the system.

3.3 Recommendation algorithm research and optimization

Recommendation algorithm is one of the key technologies of personalized recommendation system based on big data. Its role is to select the products that users may be interested in according to user profiles and product information, and recommend them from a large number of products. Common recommendation algorithms include collaborative filtering, content filtering, hybrid recommendation and so on.

Collaborative filtering is a recommendation algorithm based on user behavioral data. It analyzes the behavioral similarity between users to predict their interest preferences, and recommends products that are similar to their interests and that other users like. The advantage of collaborative filtering is that it can discover new interests of users, but the disadvantage is that it has the problems of cold start and sparsity.

Content filtering is a recommendation algorithm based on product content. It analyzes the characteristics and attributes of the product and the user's historical behavioral data to predict the user's preference for the product, and recommends the product with high preference for the user. The advantage of content filtering is that it can recommend products similar to the user's historical interests, but the disadvantage is that it is difficult to discover the user's new interests.

Hybrid recommendation is a recommendation algorithm that combines collaborative filtering and content filtering. It can comprehensively utilize the user's behavioral data and product content information to predict the user's interests and preferences, and recommend more accurate products for the user. The advantage of hybrid recommendation is that it can improve the accuracy and diversity of recommendation, but the disadvantage is that the algorithm is more complex and requires more computing resources.

In order to optimize the performance of recommendation algorithms, researchers are constantly trying to introduce new techniques and methods. For example, deep learning technology can be used to extract the deep features of users and products to improve the accuracy of recommendation; reinforcement learning technology can be used to optimize the recommendation strategy to improve the diversity and novelty of recommendation; social network information can be used to introduce the user's social relationship to improve the social and personalized degree of recommendation, etc. These new techniques and methods bring new opportunities and challenges for the development of big data-based personalized

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recommendation system. The introduction of these new technologies and methods brings new opportunities and challenges for the development of personalized recommendation system based on big data.

4. Application scenarios and case studies

E-commerce personalized recommendation system based on big data has a wide range of applications in different scenarios, the following detailed analysis of three cases to show its practical application effect.

4.1 Commodity recommendations

A large e-commerce platform uses a personalized recommendation system based on big data to recommend relevant products for users by analyzing their shopping history, browsing records, search behavior and other data. For example, when a user searches for "sports shoes", the system will recommend a series of sports shoes that meet the user's needs based on the user's historical purchase records, browsed sports shoes styles, price preferences and other information. These recommendations are not only highly relevant to the user's search intent, but also meet the user's personalized needs and improve the user's shopping experience.

Commodity recommendation is one of the most common applications in e-commerce personalized recommendation system based on big data. The realization of commodity recommendation mainly depends on the following key steps:

4.1.1 Data collection

First, the system will collect user behavior data on the e-commerce platform, including but not limited to browsing history, search records, purchase records, evaluation information, clickstream data, etc. These data form the basis of recommendation system, which can reflect users' interest preferences and consumption habits.

4.1.2 Data preprocessing

The collected raw data usually contains noise and inconsistency, and it needs to be cleaned, duplicated and formatted. In addition, it may be necessary to normalize or standardize the data, so that subsequent algorithms can process the data more effectively.

4.1.3 Characteristic engineering

Extracting meaningful features from the cleaned data can help the recommendation algorithm to better understand user needs and commodity attributes. Features can include static information such as the user's age, gender and geographical location, and can also include dynamic behavior characteristics of the user, such as purchase frequency and browsing time.

4.1.4 User portrait construction

Using the extracted features, the system constructs a unique user portrait for each user. This portrait is an abstract representation of users' interests and needs, which usually includes multiple dimensions, such as preferences, purchasing power, brand preferences and so on.

4.1.5 Recommended algorithm application

Recommendation algorithm is the core of product recommendation. According to the user's portrait and product characteristics, the recommendation algorithm will calculate the user's preference for different products. Common recommendation algorithms include collaborative filtering (recommendation based on the similarity of users or items), content filtering (matching recommendation based on the characteristics of commodity content), and mixed recommendation (combining collaborative filtering and content filtering).

4.1.6 Generate recommendation list

Based on the results of the recommendation algorithm, the system generates a personalized list of product recommendations for the user. This list usually contains the products that the user is most likely to be interested in, and is sorted according to the predicted level of interest.

4.1.7 Real-time updates and optimizations

The recommendation system monitors new user behaviors in real time, such as new search, browsing

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or purchasing behaviors, and updates user profiles and recommendation lists based on these new data. In addition, the system also regularly evaluates the effectiveness of the recommendations, and optimizes the recommendation performance by adjusting the algorithm parameters or introducing new technologies.

4.1.8 Interface presentation

Recommendation lists are presented to users through the e-commerce platform's user interface. This can be a personalized recommendation block on the home page, search results page, product details page, etc., so that users can easily discover and browse recommended products.

Through the above steps, the e-commerce personalized recommendation system based on big data can realize accurate product recommendation and improve the shopping experience of users and the business efficiency of the platform.

4.2 Ad push

An online shopping platform uses a personalized recommendation system based on big data to push advertisements. The system analyzes users' interests and preferences, shopping habits, geographic location and other information to accurately push relevant ads to target users. For example, for users who often buy mother and baby products, the system will push advertisements of mother and baby products; for users who like traveling, the system will push advertisements of traveling products. This kind of precise advertising not only improves the click rate and conversion rate of the ads, but also improves the user experience and advertising revenue of the platform.

It is a complex project to implement a personalized recommendation system based on big data in Java to push advertisements, which usually involves multiple components and a large amount of data processing. The following is a simplified example of Java program structure to illustrate how to organize such a system. Please note that this is only a conceptual example, and the actual system will be more complex.

First, we need to define a few key classes.

1) 'User': indicates the user, including the user's ID, interests, preferences, shopping habits, geographical location and other information.

2) 'Advertisement': indicates an advertisement, including the ID, content, target user group and other information of the advertisement.

3) 'RecommendationEngine': recommendation engine, which is responsible for analyzing user and advertising data and generating recommendations.

4) 'AdvertisementService': advertising service, responsible for storing advertisements and managing advertisement push.

5) 'UserService': user service, responsible for storing user information and managing user data.

6) 'Main': main program entry.

The following are simplified JAVA code examples of these classes:

```
// User.java
public class User {
    private String id;
    private List<String> interests;
    private Map<String, Integer> shoppingHabits; // Mapping of product category to purchase frequency
    private String location;

    //Constructor, getter, and setter ellipsis
}
// Advertisement.java
public class Advertisement {
    private String id;
    private String content;
    private List<String> targetInterests;
```

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```
    //Constructor, getter, and setter ellipsis
}
// RecommendationEngine.java
public class RecommendationEngine {
    private UserService userService;
    private AdvertisementService advertisementService;

    public RecommendationEngine(UserService userService, AdvertisementService advertisementService) {
        this.userService = userService;
        this.advertisementService = advertisementService;
    }

    public List<Advertisement> getRecommendedAdvertisements(User user) {
        List<Advertisement> recommendedAds = new ArrayList<>();
        List<Advertisement> allAds = advertisementService.getAllAdvertisements();

        for (Advertisement ad : allAds) {
            if (isRelevant(user, ad)) {
                recommendedAds.add(ad);
            }
        }

        return recommendedAds;
    }

    private boolean isRelevant(User user, Advertisement ad) {
        // This is supposed to be a more complex matching algorithm, but the simplified example only checks for interest matches
        return user.getInterests().stream().anyMatch(ad.getTargetInterests()::contains);
    }
}
//AdvertisementService.java and UserService.java will contain data storage and retrieval logic. The specific implementation is omitted here.
// Main.java
public class Main {
    public static void main(String[] args) {
        UserService userService = new UserService(); //  Assumed to be realized
        AdvertisementService advertisementService = new AdvertisementService(); //  Assumed to be realized
        RecommendationEngine engine = new RecommendationEngine(userService, advertisementService);

        User user = userService.getUserById("12345"); //  Obtain the information of a user, assuming that the implementation exists
        List<Advertisement> recommendedAds = engine.getRecommendedAdvertisements(user); // Get the list of recommended advertisements
        for (Advertisement ad : recommendedAds) {
            System.out.println("Recommended ad: " + ad.getContent()); //  Output recommended advertising content
        }
    }
}
```

Please note that the above code is just a very simplified example to illustrate how to organize Java programs to implement personalized advertising push based on big data. In practical applications, recommendation algorithms will be more complex, which may involve machine learning, data mining and other technologies, and need to consider large-scale data processing, distributed computing and other challenges. In addition, data privacy and security issues need to be considered.

An e-commerce platform uses a personalized recommendation system based on big data to

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recommend relevant promotional activities for users when holding promotional activities. The system analyzes which products or brands users are interested in based on their shopping history, browsing records, search behavior and other data, and then recommends corresponding promotions for users. For example, for users who often buy fashionable clothes, the system will push promotions for fashionable clothing brands; for users who like food, the system will push promotions for food products. This kind of personalized promotions not only increase the user's participation and willingness to buy, but also promote the sales growth of the platform.

E-commerce personalized recommendation system based on big data has a wide range of application value in different scenarios. Whether it is product recommendation, advertisement push or promotion recommendation, the system can provide users with personalized service experience by accurately analyzing user data and needs. With the continuous development of technology and accumulation of data, it is believed that personalized recommendation system will play a greater role in more fields in the future.

5. Conclusion

In the field of e-commerce, personalized recommendation system based on big data has become one of the key technologies to improve user experience and enhance platform competitiveness. Through in-depth mining and analysis of user data, the recommendation system can accurately understand user needs and provide users with personalized product recommendation services. This not only improves users' shopping satisfaction and loyalty, but also promotes the sales of goods and the profitability of the platform.

This paper discusses in detail the implementation process of e-commerce personalized recommendation system based on big data, including data collection and pre-processing, user profile construction and updating, recommendation algorithm research and optimization and other key links. Through the case study, it further demonstrates the effect and value of the recommendation system in practical application. It is proved that the personalized recommendation system based on big data can effectively improve the operation efficiency and user satisfaction of e-commerce platform.

With the continuous development and improvement of big data technology, as well as the increasing demand of users for personalization, e-commerce personalized recommendation system based on big data will usher in a broader development prospect. In the future, the recommendation system will realize further breakthroughs and innovations in the following aspects.

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