Web-Based Intelligent Book Recommendation System Under Smart Campus Applications

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Abstract. Recommendation systems are essential as they help users to discover new books and resources and increase their engagement and satisfaction, thus improving the overall learning experience. This paper presents a web-based intelligent book recommendation system for smart campus applications at Izmir Bakircay University. The system is designed as an intelligent hybrid tool that combines collaborative and content-based filtering techniques to recommend books to users with methodological differences. It considers the user's reading history and preferences and integrates with other smart campus applications to provide personalized recommendations. The system is important for the digital transformation of smart campuses as it helps to make education more personalized, efficient, and data-driven. Also, it allows for the effective use of public resources. The effectiveness of the system was evaluated through user feedbacks, 22 users evaluated 148 books and the results showed that users responded positively to about 70% of the recommended books thus, it provided accurate and personalized recommendations.

Keywords: book recommendation · smart campus · intelligent system · web application

1 Introduction

The digital era has brought about a tremendous increase in the amount of data and information available online, leading to the development of sophisticated recommendation systems [1]. These systems use advanced algorithms and machine learning techniques to analyze and understand user behavior, preferences, and interactions with digital content. They then use this information to make personalized suggestions for products, services, and content that are most likely relevant and exciting to the user. The integration of recommendation systems in various digital platforms has become a key strategy for businesses looking to

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improve customer engagement and drive sales. It has also changed the way people discover and consume content, leading to a more personalized and convenient user experience [2].

Book recommendation systems are important in the digital era, where the abundance of books can lead to information overload and make it difficult for users to find books that match their preferences [3]. Recommendation systems can help to alleviate this problem by providing personalized recommendations based on the user's past behavior or attributes of the books. Additionally, in the context of the smart campus, recommendation systems can play an important role in improving the overall learning experience by providing personalized recommendations and increasing student engagement and satisfaction [4].

Recommending books has become an important research topic in the field of information retrieval and machine learning, as they can help users to discover new books and resources that they may not have otherwise found. The problem of book recommendation is essentially to predict a user's preferences for a set of items (in this case books) based on their past behavior (e.g. ratings, purchase history, reading history) or attributes of the items themselves. There are several factors that make book recommendation a challenging task, including the high dimensionality of the item space, the sparsity of user-item interactions, and the subjectivity of user preferences [5]. Additionally, the high number of books available and the fast-paced evolution of the book market make it challenging to provide up-to-date and relevant recommendations [6].

A web-based intelligent recommendation system is a system that suggests items or content to users over the internet, typically through a website or mobile app [7]. Advanced algorithms and machine learning methods are employed by these systems to examine and comprehend user actions, inclinations, and engagements with digital materials. Subsequently, this data is utilized to offer tailored recommendations for products, services, and content that are more likely to appeal and engage the user. A web-based book recommendation system suggests books to users based on their preferences and reading history. It typically uses a combination of techniques such as collaborative filtering, content-based filtering, and hybrid methods to make personalized recommendations [8].

Collaborative filtering is a method that looks at the reading habits of similar users and suggests books that they have enjoyed. For example, if a user A and B have similar reading history and user B read book X but not user A, then the system will recommend book X to user A. Content-based filtering is a method that suggests books based on the characteristics of the books that a user has previously read. For example, if a user has read several books with a similar theme or genre, the system will recommend other books with similar themes or genres. Hybrid methods use a combination of both collaborative filtering and content-based filtering.

Under smart campus applications, web-based intelligent book recommendation systems can play several roles [9,10]. *i) Personalized Learning*: By analyzing students' reading habits and preferences, book recommendation systems can suggest books that align with their interests and learning goals. *ii) Library*

Management: Book recommendation systems can be used to manage library collections and improve the user experience. By analyzing the reading habits of students and faculty members, libraries can purchase books that align with their interests and needs. Additionally, by suggesting books based on the user's history and preferences, it can improve the discovery of the library's collection. *iii) Curriculum Support*: Book recommendation systems can support the curriculum by offering texts that align with the course material. *iv) Research Assistance*: Book recommendation systems can help students and faculty members find relevant research materials. Suggesting books and articles based on a user's research topic can save time and effort in finding the needed information. *v) Student engagement*: Book recommendation systems can improve concentration and participation in reading-related activities. Books that align with the student's interests can increase their likelihood of reading and participating in book clubs or reading challenges. Overall, book recommendation systems can provide a more personalized and efficient way for students and faculty members to discover, access, and engage with the library's collection and other reading materials, and ultimately improving the learning experience and academic performance.

The study proposes a web-based intelligent book recommendation system that utilizes a combination of collaborative and content-based filtering techniques to recommend books to users based on their reading history and preferences. Additionally, the system integrates with some university information systems such as personnel database, student database to provide more personalized recommendations for each individual user. The goal is to demonstrate that the proposed system is able to provide accurate and personalized recommendations for users, and that it addresses the specific challenges and opportunities of recommendation systems in the context of smart campus and digital education.

The study contributes to the field by providing a monolithic hybrid system for the web-based intelligent book recommendation that utilizes both collaborative and content-based filtering techniques, which can provide more accurate and personalized recommendations for users. The remaining part of the paper is structured as follows: Sect. 2 summarizes the related work in the literature; Sect. 2 explains the proposed system; Sect. 4 presents the evaluation results of the proposed system; and Finally, Section 5 concludes the paper by discussing the results, the study's limitations, and future directions.

2 Literature Review

Book recommendation systems are a popular research topic in the field of information retrieval and machine learning. Many different techniques have been proposed to recommend books to users, including collaborative filtering, content-based filtering, and hybrid methods that combine both approaches. Collaborative filtering is based on the idea that people who have similar reading preferences will also like similar books [11]. This approach typically uses user-item ratings or user-item interactions to make recommendations. The main disadvantage of

collaborative filtering is that it relies on the availability of user-item ratings or interactions, which can be challenging to obtain or sparse. Additionally, it can suffer from the "cold start" problem, where it is difficult to make recommendations for new users or items that do not have any ratings or interactions. Content-based filtering, on the other hand, is based on the idea that people will like books that are similar to books they have previously read or liked [12]. This approach typically uses the metadata or content of the books, such as the author, genre, and keywords, to make recommendations. Content-based filtering can suffer from the "subjectivity" problem, where different users may have different opinions about the characteristics or features of an item. Additionally, it can be difficult to extract useful features from the content of an item, especially in the case of unstructured data like books. Hybrid methods combine the advantages of both collaborative and content-based filtering, usually by using collaborative filtering to provide users with a set of items to rank and then using content-based filtering to re-rank the items [13]. Hybrid methods can be more complex to implement and require more data than either collaborative or content-based filtering alone. Some researchers proposed to use natural language processing (NLP) techniques to extract the features from the book's content and then use them to make recommendations, such as Latent Semantic Analysis (LSA) [14], Latent Dirichlet Allocation (LDA) [14], and Word2Vec [15]. Using NLP techniques for feature extraction can be computationally expensive, and it might not be the best choice if the data is not in the text format. Also, those techniques might not be able to capture the subtle nuances in the text, leading to poor recommendations.

In addition, a number of studies have explored the use of book recommendation systems in specific domains, such as e-commerce [16], libraries [3], and digital educational contexts [17], under smart campuses. These studies have shown that recommendation systems can effectively increase user engagement and satisfaction and in helping users to discover new books and resources. Overall, recommendation systems in the context of smart campuses and digital education can play an important role in improving the education experience. Still, it requires addressing the specific challenges that come with it.

Under Smart Campus Applications, a web-based Intelligent Book Recommendation System, besides its effect on users (students), such as improved learning outcomes and enhanced student engagement, can have various implications for educational managers too. These may involve both advantages and challenges that educational managers should consider. On the positive side, educational managers can consider the following:

- Efficient resource allocation: One advantage of web-based recommendation systems is that they can increase resource allocation efficiency by matching users with books and reading materials or services that best suit their tastes and requirements. This can lower the costs of service provision, publishing and distribution of physical items, and book inventory management while increasing user satisfaction and loyalty by meeting their needs [18].

- Efficiency and effectiveness of library services: By recommendation of reading materials, the tool is able to reduce the search time and cost for books, optimize the book inventory, and increase the efficiency and effectiveness of library services [19].
- Data-driven decision-making: Educational managers can get help for their operations through insights into how students engage with reading materials by collecting data on student reading habits. These data can assist them in making data-driven decisions on how to enhance their reading programs and boost student progress [20].
- Collaboration and communication among learners and educators: The tool can serve as platform that will enable learners and educators to share their opinions, reviews, and feedback on books and enhance the collaboration and communication among them [21].

However, under smart campus applications, a web-based intelligent book recommendation system poses some challenges for educational administrators as described below:

- Guaranteeing the privacy and security of the user data and feedback the system gathers, and complying with the ethical and regulatory requirements regarding data protection and usage.
- Sustaining the level of quality and precision of the book recommendations that the system generates, in addition to addressing the problems of sparsity, cold start, scalability, diversity, serendipity, and explainability.
- Assessing the effectiveness and effect of the system on the user behavior and satisfaction, and also on the learning outcomes and library services.
- Finding a balance between content-based and collaborative filtering methods, as well as between standardization and personalization of book recommendations.
- Combining the system with other smart campus applications and platforms, as well as guaranteeing its compatibility and interoperability with diverse devices and formats [22].

Under this literature review, this study proposed a web-based hybrid intelligent book recommendation system as a smart campus application. The hybrid system is monolithic and consists of collaborative filtering and content-based filtering.

3 Proposed Hybrid System

The Web-Based Hybrid Intelligent Book Recommendation System shown in Fig. 1 is comprised of three key components: Data Sources, User Interaction Applications, and a Python API. The system integrates information from three data sources, including the Library for books, Personnel Affairs for university employees, and Student Affairs for students. This information is then utilized to make personalized recommendations to users through User Interaction Applications. Users can get suggestions in two different ways. Firstly, they can access

both their own data and suggested books by logging in through the web-based interface. Secondly, the system can send email notifications to users with book suggestions at specified intervals. There is a communication between User Interaction Applications and Python API components. User Interaction Applications make a request to the API with the user ID, and the API returns a list of suggestions to the user by performing the necessary calculations.

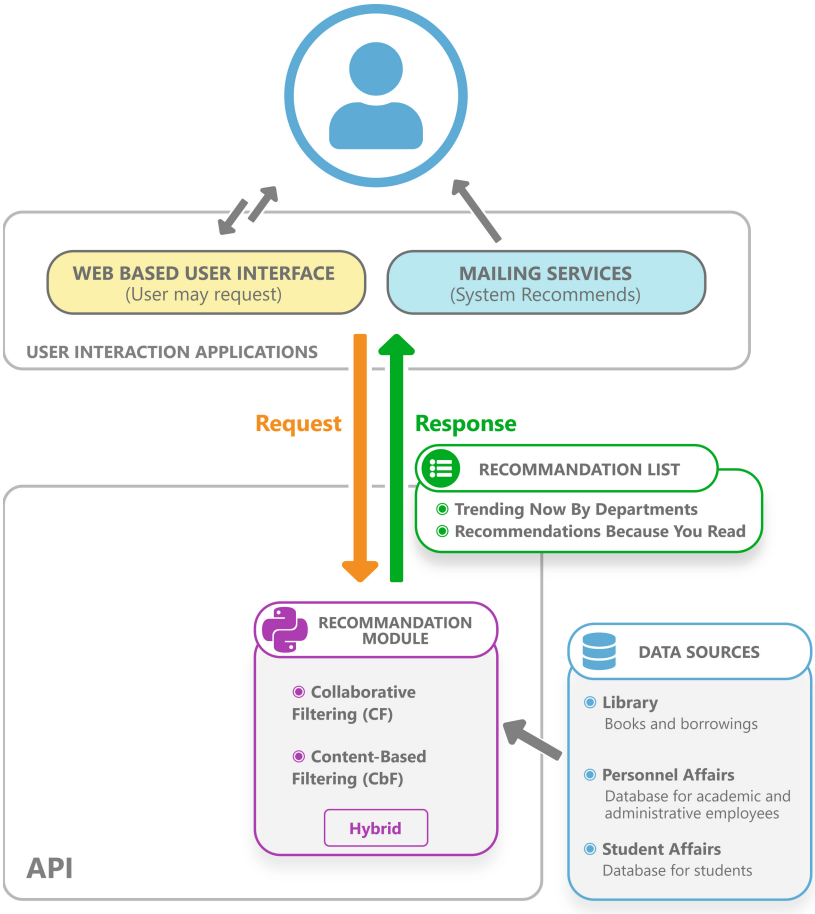

Fig. 1. System architecture

The Recommendation Module, which is designed as a Python API, uses a hybrid technique that combines Collaborative Filtering and Content-Based Filtering to make its recommendations. A monolithic hybrid system that combines collaborative and content-based filtering techniques can overcome the disadvantages of both methods by leveraging the strengths of each approach. Collaborative filtering is a powerful technique that provides recommendations based on the similarities between users or items. However, it has some limitations, such as the cold start problem, where it can be difficult to make recommendations

for new users or items without any prior ratings or interactions. Additionally, it can be susceptible to popularity bias, where popular items tend to be recommended more often than others. Content-based filtering, on the other hand, provides recommendations based on the similarity between items and the user's preferences. This approach is able to handle the cold start problem by using item characteristics to make recommendations. Still, it can suffer from limited scalability and difficulty obtaining accurate and complete item descriptions.

By combining these two methods, a hybrid system can address these limitations. The collaborative filtering component can provide recommendations based on user-user similarities, while the content-based filtering component can provide recommendations based on item-item similarities. This combination can overcome the cold start problem by leveraging item characteristics while also addressing the limitations of content-based filtering by incorporating user preferences. Furthermore, by combining the two methods, a hybrid system can provide a more diverse set of recommendations and avoid popularity bias. By considering both user and item similarities, the hybrid system can make recommendations tailored to the individual user's preferences while also incorporating the wider community's opinions and behaviors.

The algorithm steps of Recommendation Module are given in Fig. 2. This module first runs the Collaborative Filtering Model by using Library, Personnel Affairs and Student Affairs data sources. Books and users borrowing these books are obtained from Library data sources, academic and administrative personnel information is obtained from Personnel Affairs, and student information is obtained from Student Affairs. In this model, neighbourhood-based similar and unsimilar students are found after the student-book matrix is created to make basic calculations about borrowed books. This first list created with Collaborative Filtering is used for Content-based Filtering. In this second model, potential recommendations are created by removing the books that have already been read from the first list data. Then, books with content matching the user's interest are found. A list of books is created by considering the similarities. The final list of recommendations is then returned as the response.

4 Evaluation

After the system was developed, it became available to users for testing and their feedback was collected. Figure 3 presents the user interface for the part of the evaluation of the recommended books. All users were able to enter the system and saw some descriptive statistics such as the most read books in the university and the user's department, library usage ratio, the number of borrowed books and users, and read book list. The most suitable ten books were recommended to the user by the improved system and evaluating the recommended books was requested by the user with 'Suitable' or 'Unsuitable'. Although ten books were recommended, some users did not evaluate some recommendations. While 103 of the 148 feedbacks obtained from the 22 users were positive, the remaining 45 were negative. Precision, Recall, and F1-score were used to measure the performance of recommendations.

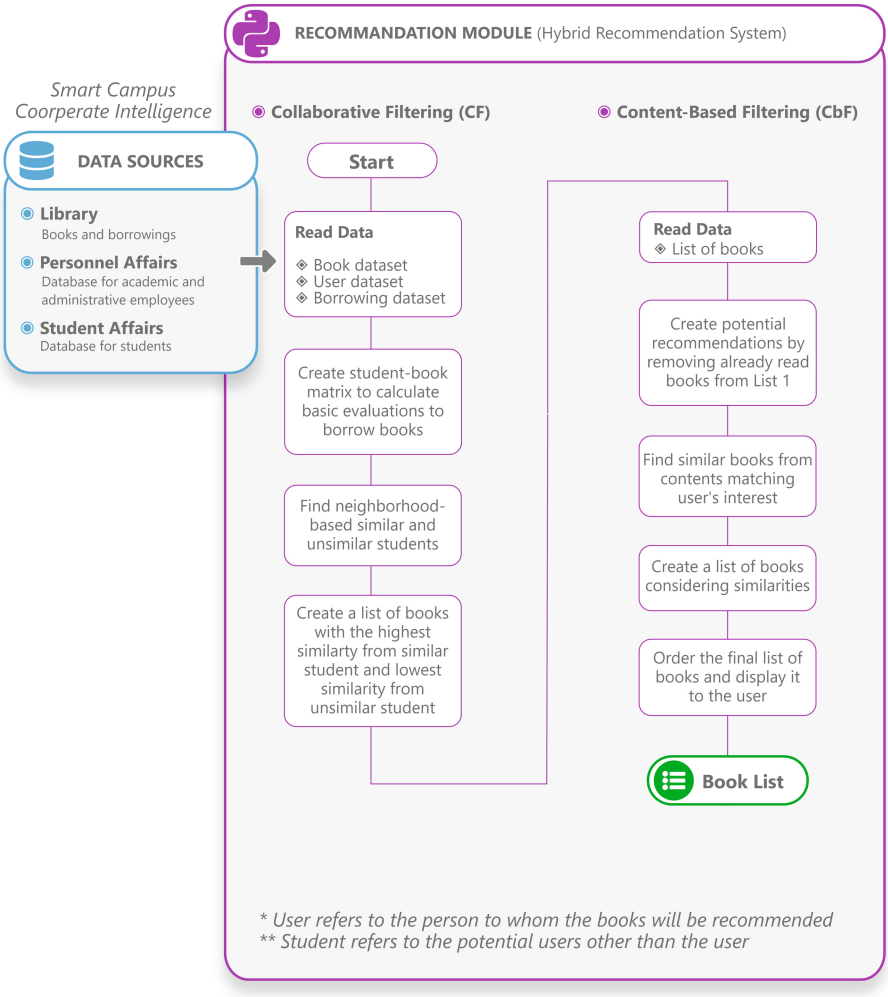

Fig. 2. Recommendation algorithm flowchart

Precision value is calculated by dividing the number of correctly recommended books (CR) by the number of evaluated recommended books (ER). Precision indicates the rate at which the system makes correct recommendations. In this study, the Precision value is calculated as 0.70. This means that 70% of recommended books were liked by users.

$$Precision = \frac{103}{148} = 0.70$$

Recall value is calculated by the presence of preferred books in recommended books. Recall value is obtained by dividing the number of correctly recommended books (CR) by the total number of recommended books (TR). It is the measure

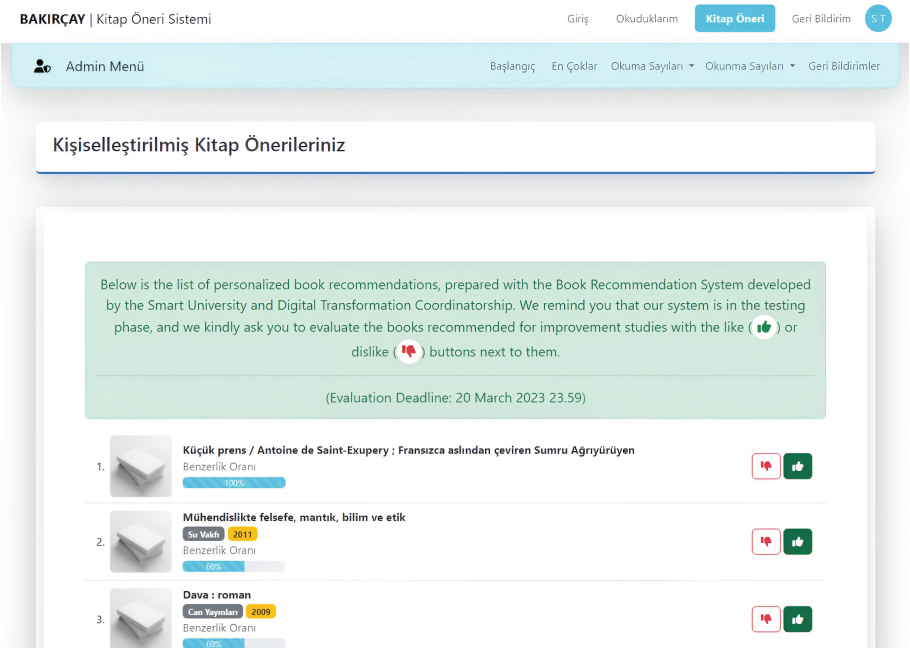

Fig. 3. User interface for evaluation

of the percentage of actual positive instances that were correctly identified by the model. Although the total number of recommended books is 220, 72 books were not evaluated by the users. Therefore, recall and F1-score were calculated under optimistic, realistic, and pessimistic scenarios. The optimistic scenario considers all unevaluated 72 books are suitable, the realistic scenario supposes unevaluated 72 books are suitable with the precision ratio of 0.70, and the pessimistic scenario assumes all unevaluated 72 books are unsuitable. The optimistic, realistic and pessimistic Recall value were found as 0.80, 0.70, and 0.47, respectively. The realistic recall score indicates that the developed system identifies positive instances by 70%, even if it incorrectly identifies some negative instances as positive.

$$Recall_o = \frac{103+72}{220} = 0.80, Recall_r = \frac{103+72\times 0.7}{220} = 0.70, Recall_p = \frac{103}{220} = 0.47$$

F1-score, on the other hand, is harmonic mean of precision and recall and considered a good criterion as it shows the balance between precision and recall [6]. It is calculated by $2 \times precision \times recall/(precision + recall)$. The F1-score of the realistic scenario is 0.70. This indicates a good balance between Precision and Recall, with system performance being good.

$$F1_o = 0.75, \quad F1_r = 0.70, \quad F1_p = 0.56$$

5 Conclusion and Discussion

This paper presented a web-based hybrid intelligent book recommendation system developed with a hybrid method that uses content-based filtering and collaborative filtering methods. The system provided personalized recommendations to users based on their reading history and data collected through the Smart Campus applications. The aim was to process the data provided by users and produce functional outputs while also enabling them to make more efficient and effective use of library resources, which were established at high cost, by improving the user's experience with the library resources.

After the system was developed, it was made available to users for testing, and feedback was obtained. The precision, recall, and F1-score values of the recommendations were calculated based on the feedback received. Based on the feedback obtained, the precision value was 70%, indicating that the majority of recommendations made were relevant to the user's needs. Because some users did not evaluated all recommended books, three scenarios were defined for recall and F1-score. The realistic recall value was 70%, indicating that a high proportion of relevant recommendations were made. The F1-Score under realistic scenario value was 70%, indicating that the system's performance was moderate in terms of both precision and recall.

The disadvantages of the recommendation techniques are given above. In general, it is essential to note that any recommendation system is only as good as the data it is based on and that the quality and quantity of the data can significantly influence the effectiveness of the recommendations.

Research in the field of book recommendation systems has demonstrated the potential for various domains to improve the user experience and help users to discover new books and resources. However, more research is needed to fully understand the different factors that influence the effectiveness of book recommendation systems and to develop more accurate and personalized recommendations.

The proposed recommendation system requires to have a user history. For future directions, the authors plan to improve the current system for new users through additional techniques such as fuzzy association rule mining. Moreover, the hybrid system will be extended by a fuzzy rule generator to prioritize the book lists produced by the current recommendation system by considering various prioritization criteria such as the total number of borrowed books, the similarity scores of the books that the user borrowed in the past, and the publication year of the book.

Overall, and as presented in this work, within the framework of Smart Campus Applications, a Web-based Intelligent Book Recommendation System can be a helpful tool for improving student learning outcomes, boosting engagement with reading materials, and providing educational management with information to influence decision-making. It can also assist educational administrators in properly allocating resources and making data-driven choices. However, it is critical to tackle the related challenges that were mentioned, something that could be a topic for future research.

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