

Machine Learning Techniques for Book Recommendation: An Overview

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ARTICLE INFO

Article history:

Received 15 January 19

Received in revised form 30 January 19

Accepted 24 February 19

Keywords:

Book Recommender System

Machine Learning Techniques

Collaborative Filtering

Content-Based Filtering

ABSTRACT

Recommender Systems are intelligent systems which are used as an expert in making decisions in real life problems. They have replicated the human experts and positively affected the e-commerce by changing the behavior of customers and sellers. Book Recommender Systems (BRS) help the librarians in the management of library catalog efficiently. It supports the readers in choosing the best book for them. Merchants implement the BRS to manage their inventory and gain more profit. In this paper, we have discussed traditional techniques of recommendation, machine learning techniques and their categories i.e. supervised, unsupervised, semi-supervised and reinforcement learning. Also, Machine Learning (ML) techniques used for the book recommendation and their effect on book recommender systems have been discussed. The work will help the researchers in exploring new dimension for recommendation technology in general and book recommendation in particular.

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Peer review under responsibility of International Conference on Sustainable Computing in Science, Technology, and Management.

1. Introduction

The growth of the internet and advancement in computing technologies has touched every aspect of human being. Nowadays computers are being implemented in almost every domain of life to replicate the manual system and to reduce the workload of humans. Recommenders are a type of intelligent systems which are implemented to replicate human experts. They have been implemented in various real-life applications to assist people in decision making. In e-commerce recommenders have been implemented to help the buyers in choosing the most suitable product for them and to increase the profit of merchants by selling more products. Book recommenders have been designed considering the changing pace of time. They are implemented in libraries for their maximum utilization. By mining the borrowing records of libraries it suggests the librarians the books to be purchased. On the basis of browsing history of a library user a recommender suggests him the books which he may like or which are related to his area of study if he is a student or a teacher. Similarly, a book recommender applied in e-commerce domain suggest the merchants about the different books and help him to manage his inventory. It also helps the user in purchasing the most appropriate book for him considering various criteria like his preferences, cost and other features of the book (Sohail, Siddiqui, & Ali, 2018).

Machine learning (ML) is one of the fascinating and fastest growing field of this era. ML techniques are being implemented in almost every domain of computing. They have been implemented in BRS to improve the predictive and recommendation accuracy of the system. These techniques have been utilized for extraction and classification of book features. Human sentiments and their choices have also been extracted using these. After finding sentiments, choices, browsing history, and features of books similarity is calculated and recommendations are generated. This paper is a study on machine learning techniques which have been implemented on book recommenders. In this paper we have reviewed how ML techniques have been implemented in BRS, what is the benefit of using a particular technique, what other techniques can be used for further improving the recommendation systems and what are the applications of BRS.

This paper starts with introduction in section 1. In section 2, we have discussed traditional recommendation techniques, then in section 3, machine learning techniques have been discussed which is followed by literature survey in section 4, and ends with conclusion and future works in section 5.

2. Recommendation Techniques

In this era of information and communication technology, Recommender Systems (RS) are helping internet users as expert. They help the users in making the decision in day to day life about what to purchase, which show to watch, which place to visit etc. Recommender systems (RS) try to identify the need and preferences of users, filter the huge collection of data accordingly and present the best-suited option before the users by using some well-defined mechanism (Sohail, Siddiqui, & Ali, 2017). RS are beneficial to both the users and service providers (Pu, Chen, & Hu, 2011). They have also proved their importance in decision making and have improved the quality of decision making. The mechanism used by RS in filtering the data can be broadly classified into three main categories as collaborative filtering (CF), content-based filtering (CBF) and hybrid filtering approach

2.1. Collaborative Filtering

CF is the most preferred techniques used to design recommender system. Traditional CF recommendation technique works using the analysis of the historical user-item rating data, find the other like-minded users, predict the ratings of the item for the target user and generate the recommendations. It predicts the user behavior from the past habits of the user and finds a relationship between two or more users based on their past activities and recommend similar products to similar users. These similar users are termed as neighbors. CF technique is used in almost all domain of data set in recommender system.

2.2. Content based Filtering

CBF recommender system are developed based on previous history of user. It considers that if a user has liked or favored any item in past, he will also favor that in future. The similarity of items is evaluated by the detail of features of the item. For CBF to operate, attributes of the items you wish to recommend must be extracted. Two challenging problems of CBF are limited content analysis and overspecialization (Adomavicius & Tuzhilin, 2005). The issue of lack of content analysis emerges due to inability to extract useful contents from various data items like text, images, audio, video etc. Due lack of proper content information the quality of recommendation degrades. The problem of overspecialization is caused to due to the suggestion of only those items which are very much same as the items favored by the user. This denies the user from getting some novel and serendipitous suggestions which he may have liked or which are according to his need. Due to the limitations of CBF, it is rarely used in pure form instead it is used with blending with some other technique.

2.3. Hybrid RS

CF technique of recommendation is the highly used technique but it suffers from the issue of cold start. Similarly CBF suffers from overspecialization and limited content analysis problem. To overcome all these issues researchers tried some alternative and designed hybrid techniques which are the combination of CF and CBF. Hybrid techniques utilize the useful features of both and try to eliminate the problems. There is not a single hybrid technique of recommendation. But many hybrid techniques are designed using different combination of CF and CBF. The authors (Sohail et al., 2017) have discussed seven categories of hybrid techniques. Hybrid techniques increase the computing load of the system. But due to the availability of powerful computing machines, these techniques are frequently used in many recommender systems. Recently hybrid techniques are used in almost every domain of recommender like movie, book, e-commerce, hotel, and tourism etc.

3. Machine Learning

We are living in an era of digital technology. Almost every activity of this generation is performed by machines. This has been possible due to the advancement in computing and artificial intelligence. Machine learning (ML) is one of the sub category of artificial intelligence which has given the birth to machines which learn by experience and are performing the tasks which are supposed to be performed by human being without being explicitly programmed. ML techniques are being utilized in various domain of life. They are working very much similar to humans. Nowadays Automatic cars are being driven by ML algorithms, expert system in medical field are being used to diagnose the disease, they are being used to detect fraud transaction in banking, Natural Language Processing is being performed using ML algorithms. ML is different from conventional computing as normal computing algorithms are programmed exclusively to perform a specific task, they always work according to programmed instructions but ML algorithms are based on models created by computers. They learn by themselves from input data, gain experience and help the computers in decision-making process. There are generally four categories of ML algorithms. They are categorized as supervised, semi-supervised, unsupervised and reinforcement learning algorithms. Regression and Classification are the major objectives of supervised learning. Regression is a statistic based model which takes into consideration the relationship between different models and predicts the numeric values for unknown variable. Whereas classification identifies the category or class of new data items which is predicted based on experience gained from training data.

3.1. Supervised Machine Learning

Supervised machine learning (SML) techniques build models of classification and regression which are predictive. They make use of two types of data sets i.e. training data set and test data set. The algorithms are trained using training data set to build a general predictive function which can assign unknown data items to their appropriate class correctly. Some of the extensively applied techniques are decision trees, support vector machine, random forest, k-nearest neighbor, similarity learning, neural network, linear regression, logistic regression, and Naïve Bayes. Regression techniques include linear regression and logistic regression. They are applied to predict the result of continuous data. Whereas to predict discrete results classification approaches are used. The classification approaches are applied where the data items need to be categorized based on their features. They are used in medical diagnosis to predict the level of disease. They are used to classify emails into good or spam categories. SML approaches are also being applied in natural language proceeding, sentimental analysis, social network analysis and in opinion mining research

3.2. Unsupervised Machine Learning

Unsupervised learning (USML) techniques find the similarities among the data items which are unlabeled and group the data items which are more similar to the same category. Clustering and association rule mining are major USML techniques. Clustering is the formation of clusters of similar items. The number of clusters is unknown initially. It is dependent upon the features of the data items. If the features of data items are more heterogeneous then there will be more number of clusters and vice versa. Association rule mining is related to finding rules which show the trend of some series of activities which may occur one after another. Like in finding the purchasing behavior of customers by seeing their purchase history or in finding the borrowing pattern of book borrowers in libraries or predicting the next site a person will visit by seeing his internet surfing history. These approaches are being used in many real-life applications.

3.3. Semi-Supervised Machine Learning

SML techniques are concerned with labeled data whereas USML are used to deal with unlabeled data. Semi-supervised learning (SSML) is the blend of both the supervised and unsupervised learning approaches. SSML approaches are designed to take advantage of blending of SML and the USML algorithms. They classify the unlabeled data set using the labeled data set. SSML approaches are being used in many application of modern era. In medical science, they are used for classification of protein sequence. They are applied in web mining to classify web content. Natural language processing tools make use of SSML models to analyze the speech.

3.4. Reinforcement Learning

Reinforcement (RL) is also an emerging and powerful learning technique. In this, an agent is trained in doing some task, but there are multiple situations in reaching the goal. So the agent will take some action to reach the goal with optimality. The RL is also known as goal-oriented algorithm. The autonomous agent get reward for each of its action, and agent takes further actions depending upon the outcomes of the previous action. RL problems are generally solved using three basic approaches. They are value-based RL, policy-based RL, and model-based RL. There are many real life problems which are being solved using RL. Some major application areas are game playing, robotics and control system, designing agricultural equipment etc.

4. Literature Survey

There are various ML techniques, but all have not been used in BRS. In this section, we have discussed ML techniques which have been implemented in BRS along with the survey of papers incorporating these techniques. Fig. 1 shows Classification and application of BRS. We have classified BRS into two types of techniques i.e. traditional recommendation techniques and ML techniques used for BRS. There are four applications of BRS i.e. library catalog management, suggestion for readers, inventory management and profit generation for merchants.

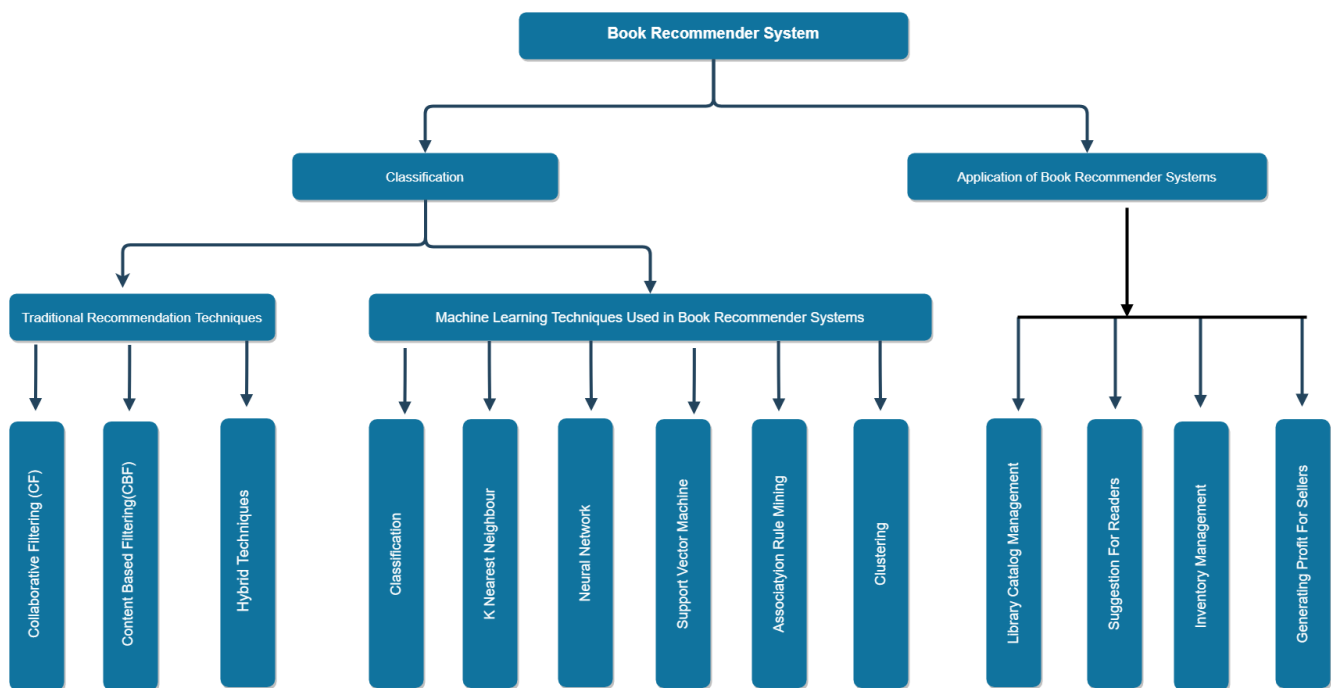


Fig. 1 - Classification and application of BRS

4.1. Classification

Classification is one of the extensively used technique which belongs to the family of SML techniques. This technique extract the features of a data element compare them with the features of the members of given classes and assign them appropriate class according to their characteristics. The intelligence of predicting membership is acquired through learning by training data. Classification technique is applied in various domains like medical diagnosis, business, sentimental analysis etc. They have also been applied successfully in recommender systems to recommend various products and services. In (Tewari, 2014a) proposed a book recommender system using classification technique along with association rule mining and item-based CF to recommend books for college students. This is multi-criteria recommender system which make recommendations based on criteria's like price, publisher, category and subcategory of the book. (S. Yang, 2012) (Cui, Li, Wang, & Yang, 2014) (S. Yang, 2012) designed recommendation models for book acquisition in libraries using classification and text mining technique. (Priyanka, 2015) applied classification along with opinion mining to make personalized book recommender system. The authors in (Zhang, Xiao, & Bu, 2017) have executed classification for personal recommendation of books in libraries of China.

4.2. *k*-Nearest Neighbor

The KNN belongs to the category of SML algorithms. It is one of the existing classification algorithms used to assign objects to its class based on its distance. In this technique, the KNN function is determined locally and till classification, all the calculations are postponed. In training stage, there is no real learning but a dataset for training is needed which is used only to populate the model of the search space along with instances whose class is already known, Therefore it is also called lazy learning algorithm. This implies that no generalization is performed by the points of training data but it is required during the testing stage. When a new data point with unknown class is introduced, the first task of KNN algorithm is to find K nearby neighbors then the allotment of class is carried using voting mechanism. KNN is an efficient algorithm for pattern recognition. It is also used for text categorization and classification. Using these features of KNN (Sabitha & Choudhury, 2018) proposed an approach for Book recommendation. The approach was tested using dataset from book crossing community, Rapid Miner data mining tool was used for retrieval of information. Rapid Miner provides two similarity measures that are Cosine and Pearson. In this approach, Pearson similarity measure was used to calculate the similarity between two data items. The system of the system was evaluated using Mean Absolute Error (MAE) and Root Mean Square Error (RMSE) metrics.

4.3. Support Vector Machine

SVM is a kernel-based technique which is used for categorization of binary data. It has its base in learning theory of statistics. It has been efficiently utilized to resolve the problem of relative minima and high dimensionality. As this is computationally robust, so it has significantly improved the performance of generalization in comparison to other techniques of machine learning. SVM has been successfully implemented and produced quality result in various applications of data mining such as time series prediction, image processing, pattern recognition, and text categorization. (Mikawa, Izumi, & Tanaka, 2011) has used this technique in book recommender system. The system recognizes the gender of the moving person and recommends the magazine to the person based on gender. The developed system has shown a very high recommendation speed.

4.4. Neural Network

Neural Networks (NN) are models which are inspired by human brain. They are made up of neuron and synapses. The standard model of NN is consist of nodes which are neurons or their clusters which have weighted links for interconnection among them. The influence of the sender on receiver neuron is directly proportional to the weight of the link between them. That is if the weight of a connecting node is more than sender have more influence on the receiver and if the weight of a link is less then influence is also less. The activations in the nodes of a NN comes from the sending to the receiving nodes. The amount of activation in a receiving node is the sum of the product of sending nodes with the weight of their respective links. This activation is transferred to other subsequent nodes based on some predefined criteria. Neural Networks are sophisticatedly designed complex structures which can perform very sophisticated tasks. They have a wide range of applications in various domains like cognitive science, pattern recognition, image processing, neurosciences, and medical diagnosis etc. They have also been used to improve the recommendation accuracy of various recommender systems. The authors in (Xin, Haihong, Junde, Meina, & Junjie, 2013) applied CF along with blending SML to recommend books in academic libraries. It has taken the rating information from the borrowing record of the user. It has predicted that for how long the user will be interested in borrowing a particular book. The technique has been evaluated by using two evaluation metrics Root Mean Square Error (RMSE) and Statistical Ratio (SR) and it has been proved that blending NN outperforms the blending with Linear Regression (LR). (X. Yang & Zeng, 2009) have used ARTMAP NN for the recommendation of books in the university library. They have made preference vectors and have classified user's profile based on their features. The recommendation has been generated according to classes. The performance of the system has been compared with the old borrowing record of the library.

4.5. Association Rule Mining

Association Rule Mining (ARM) is one of the efficient technique to discover the relationship between items of a large dataset. It comes from the category of unsupervised machine learning techniques. It is based on two steps. One is Minimum support and second is confidence. In first step data elements up to a fixed minimum frequency are sorted out. This minimum frequency is known as support. After that association rules are applied to find the related elements. This is known as confidence. There are two categories of ARM techniques i.e. (i) Pattern Growth and (ii) Level wise. There are various application of ARM ranging from software defect prediction (Czibula, Marian, & Czibula, 2014) to medical diagnosis. They have been frequently used in business application to predict the purchasing behavior of consumers and in RS to recommend products and services. This is most extensively used machine learning technique in BRS(Sohail, Siddiqui, & Ali, 2013)(Sohail, Siddiqui, & Ali, 2014). The authors in (Joshua et al., 2016) have used this technique to generate frequent pattern and to make book recommendation in libraries for the optimum utilization of books. (Ali, 2016) used this technique along with table of content and opinion of users to recommend books. The system has been evaluated using precision, recall and F measures. (Jomsri, 2018) has used FUCI mining to recommend books in the library. He evaluated the system using precision and recall and found out that this shows better accuracy than other techniques. (Jomsri, 2014) has designed book recommender system for digital libraries. He has used user profile and his browsing history to apply this rule. (Tewari, 2014a) used this algorithm to design a system for e-commerce to recommend textbooks for students. The authors of (Maneewongvatana & Maneewongvatana, 2010) has used association rule mining and clustering for the recommendation of books. They have evaluated the system performance by asking questions through a questionnaire and found that users were satisfied by the performance of the system. (Zhu & Wang, 2007) has used circulation history of the library and applied an improved version of this technique to generate personalized recommendation of books. (Lina & Zhiyong, 2013) have designed intelligent recommendation system for books using association rule mining technique. To implement the algorithm they have used clementine software developed by SPSS. (Kuroiwa & Bhalla, 2007) have collected reviews about books from web sources and after pre-processing those reviews applied association rule mining to generate recommendation to enhance the virtual library. (Mariana, Surjandari, Dhini, Rosyidah, & Prameswari, 2017) has developed a recommender for OPAC of the library of the University of Indonesia. They have applied this technique for mining frequent and infrequent item sets. (Hwang, Lim, & Avenue, n.d.) has proposed a recommender for books that have never been borrowed from the library or borrowed rarely. This proposal

is from other book recommenders in the sense that it has applied association rules on the profile of users. Therefore this technique can also be applied on other recommendation systems which are being used in other domains like e-commerce, movies etc. the authors in (Saxena, Singh, & Khan, 2014) developed web base recommendation system which uses association rule and frequent pattern analysis to generate a recommendation. (Rajpurkar, 2015) used this approach in combination with CF and CBF for generating a recommendation for online website. (Liu, 2018) has applied association rule along with CF to improve library recommendation system. They also have evaluated the system along with precision and recall. (Tewari, 2014b) have used this approach along with hybrid recommendation technique for the recommendation of books. In (Luo, 2012) have designed a system which utilizes association rule mining for the recommendation. It generates recommendation rules from the database of sold books.

4.6. Clustering

Clustering is unsupervised learning approach of machine learning. It partitions a given data set into multiple subsets which are disjoint and each subset contains data elements which have similar attributes. The similarity of elements of the subset is calculated based on different criteria which may vary in different datasets. The divided subsets are known as clusters based on which the approach is called clustering. The no of clusters in the clustering approach is unknown. The main goal of clustering is to group the similar elements into same group or cluster so that different features of a given data set can be studied. Clustering techniques are being used in various domain like pattern recognition, image processing, bioinformatics (McGarry, 2013)(Xu & Su, 2015)(Mikawa et al., 2011) etc. . The authors in (Maneewongvatana & Maneewongvatana, 2010) has applied k mean clustering for the recommendation of books in the university library. They have browsed the borrowing history of the library and after cleaning the data they have distributed it into different clusters according to the similarity of subjects. Then association rule mining have been implemented to recommend the books. (Lina & Zhiyong, 2013) have also applied k mean clustering along with association rule mining using Clementine to make a personalized book recommendation. They have not used any evaluation metric to measure the accuracy of the system.

5. Conclusion and Future Works

In this paper, we have discussed the book recommender system and its impact on library management, benefits of BRS to librarians, students, other library users, and booksellers. We also have discussed traditional recommendation algorithms, machine learning techniques and their major classes. We have also discussed MLT applied in BRS and their impacts on BRS.

In future work, we will design a framework for applying MLT in BRS, and will study in which stage of recommendation each MLT is used, how other MLT's which have not been used in BRS can be incorporated to improve BRS. What are the challenges in implementing MLT's in BRS and what are the advantages and disadvantages of using MLT's in BRS.

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