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Collaborative Filtering Based Personalized Hybrid Recommendation System Using Machine Learning Techniques

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ABSTRACT
The sizzling growth of e-commerce platforms, online social networking websites, and online media has led to abundant information and choices, making it challenging for users to find what they want. Recommendation systems have arisen to solve this problem, proposing customized and relevant things to users based on their previous behaviour, interests, and context. Collaborative Filtering (CF) is an important part of recommendation systems approaches and it is most widely used in implementation of personalized recommendation systems. The machine learning techniques such as Matrix Factorization (MF) is a popular technique used in collaborative filtering, which is used to extract underlying factors from the user-item rating matrix. Another technique such as Neural Network (NN) has also been widely used in recommendation systems. In this paper, the use of matrix factorization with neural network have incorporated and suggested.

KEYWORDS: - E-commerce platforms, Social networking websites, Recommendation systems, Collaborative filtering, Matrix factorization, Neural network.

1. Introduction

Due to a large amount of data and the length of time analyzed, it was filtered and processed before moving on to the recommendation approach. The Hadoop framework developed a recommendation for big data availability on online ratings, opinions, reviews, complaint remarks, and feedback about goods bought using a hybrid filtering approach on numeric data rating or ranking. When applied over a big data recommender model, collaborative filtering does not return scalability with accuracy. In a commercial recommender system evaluated by large item sets, the user product matrix employs extremely sparse collaborative filtering and problems predictions of the collaborative filtering that are more demanding.

One point is that information separation is a more critical challenge in any filtering approach. The rating in many conditions, such as a new customer or item interested in this system, and it was hard to find similar indexes due to a lack of information. Another point is the data coverage, defined as the percentage of products for which the method provided recommendations. Mainly the coverage issue occurred if some user's ratings work on a small scale compared to the large item within the model, and the recommender could not generate commendations. Neighbour transitively refers to issues with spares information and database datasets in which users with similar testes many not be identified because they did not rate the same products. In this case, the efficiency of the recommendation degrades. Basically the recommendation systems falls into many categories, such as collaborative filtering approach, content based filtering approach, the combination of collaborative and content based hybrid filtering approach, knowledge based demographic based approaches.

2. Objectives

Two prominent methods for building recommendation models are neural networks (NN) and matrix factorization (MF). MF models leverage the user-item interaction matrix to discover latent features that characterize user preferences and item attributes, enabling personalized recommendations.

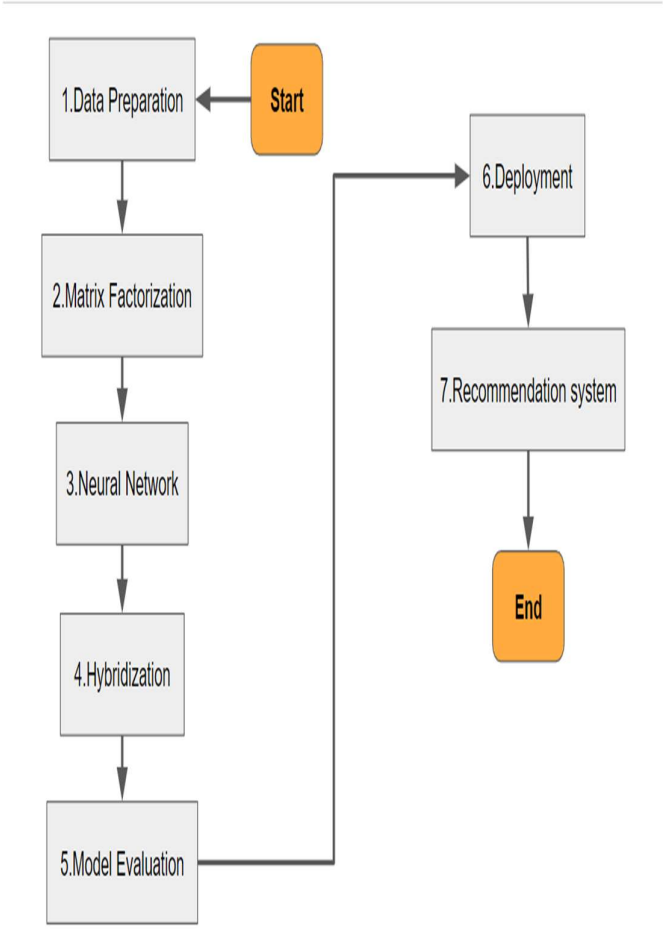

Figure 1: Proposed Methodology

3. Scope and Methodology

With the growth of web users and items, it is very difficult to find the proper data needed for the web users at a time. Although recommendation systems problems are solved by the many researchers to make recommendations more effectively but still some challenges are there as follows:

- **Acquiring known ratings for customer-item matrix** – Many times it has been identified that a large number of the customers does not suggests any preferences or choices. So it is an important issue that how to know whether the customers are satisfied with the item and how much.
- **Lack of sufficient data**- The largest issue facing by recommendation system is that the user wants a large amount of data to successfully make recommendations.
- **Changing frequent data**- Another big issue in recommendation system is changing frequently user's data. As one can say that the recommendation systems collect user data based on their past activities.
- **Changing user preferences**- Another important issue in the recommendations system is changing user choices as well as making coordination with highly changing needs of the current user.

4. Literature Review

Content-based Filtering Technique

With the advent of e-commerce, the term Recommendation System is undergoing a very fast revolution in approximately all parts of the daily life. These systems have been applied to numerous areas, such as product recommendations, songs or movie recommendations, content or news recommendations, home pages or WebPages recommendations. Several organizations have occupied and promoted recommendation systems, such as the mobile recommendation system of Amazon sites or any other product purchasing or buying from the web sites [1].

The Pearson correlation coefficient has not been implemented in the Collaborative filtering technique. Instead, a new concept has been implemented, but after implementation, a new concept has an issue i.e. divides by null error. Generally, such an error occurs after the customers have given the same rating to the specific products. In the case of the pure content-based filtering technique, the authors have used a cosine similarity matrix by taking the genre of the product, such as if the product is a movie system. Then the genre is movie writers, movie cast, movie producers or directors, so many

techniques show results based on collaborative filtering techniques and recommendations based on content-based recommendation systems [2].
The authors wrote about personalized and non-personalized recommender systems. They further explained user-based collaborative filtering and content-based collaborative filtering approaches very well. The authors have also mentioned the benefits and drawbacks of content filtering and collaborative-based filtering recommendation systems [3].
Content-based filtering approach and Collaborative based filtering approach and finally projected a result with a combination of both, i.e. Hybrid recommendation system. The authors named a technique cosine similarity. Their recommendation system gets 30 movie recommendations using this cosine similarity. After applying this similarity matrix, they filter these movies based on the SVD matrix and their user rating. This system considers only the new movies the user has seen because the authors have implemented a solution which takes as input one by one movie [4].
The authors proposed a system consisting of a system like Preprocessing of data, Principal Component Analysis (PCA), Preprocessing for neural networks and constructing the neural network. To complete this approach, several considerations have been taken user preference, user ratings, user behavior, User Consumption Ratio (UCR) etc. After applying the clustering approach, the authors used a Neural Network to calculate the ratings of products the user might give to the unwatched products. Finally, recommendations are made with the support of calculating high-rating products [5].
F. Rodriguez et al. wrote a solution for item recommendation based on the user's similarity matrix. In this paper, the authors have mentioned City Block Distance Factor (CBDF) and authors confirmed that the recommendation system is based on one of the most important techniques, which is the content-based filtering technique, and suggests the user rating matrix. The major issue in this approach is that the authors neither stated the parameters used in this matrix nor they have stated about the working model of this system [6] .
Several techniques use a collaborative filtering approach based on users' likes and preferences. Meanwhile, content-based filtering techniques use data about a product itself to make suggestions. With the use of this approach, users can recommend unrated products also. This paper applies a content-based filtering recommendation approach that utilizes information withdrawal and some machine learning algorithms for specific pattern matching [7].
Several machine learning approaches can assist with this task by recommending a song, movies, books, and any specific item recommendations. In this paper, authors have developed an algorithm using the Python system library, which implements a recommendation system based on the content of research papers. To achieve this goal, the detailed subjects cross-authorize factors in the algorithm and generate a similarity metric that maximally links with human opinions [8].
The authors presented an idea that can be found in ants and other human beings, Such as ants roaming around the walls of the house, often pursuing a line and finding food. Because ants can leave signs for other ants to help other ants for food, they suggest a highly related system to this research field, such as social networking. This concept is also used in social navigation and can be used for social information reuse. The recommendation engine or system can be defined as the system to select similar behavior whenever the customers like incredible products, such as suggesting songs, movies, mobile phones, books or any other products or friends on social networking sites [9].

Collaborative-Based Filtering Technique

The authors wrote that it is an information-filtering appsroach to finding several products presented on World Wide Web. These products are based on customers' interests, such as songs, movies, books, mobile phones, research papers and friends on social networking sites. Therefore it needs a competent searching and filtering technique to find excellent research articles so that the attempt and time of researchers can be saved. The ratings or preferences are made by the customer, who will be dogged by the number of correct ratings they provide. The output of these ratings is then sorted using a cosine similarity matrix technique. The authors propose this paper using a collaborative filtering technique to recommend a customer or research scholar with the best research article in their field [9].
The authors suggest that researchers have engaged multiple heuristics approaches in recommendation systems along with conventional methods of collaborative filtering technique. In this paper, the authors introduced a Bat Algorithm (BA). This algorithm is based on a heuristic approach. This approach has been used to compute the weights of features. The aim of these weights features is to find better neighbourhood value of the existing or active customer. In this paper, the authors also explain that giving weights to heuristics methods helps search for a better, most adapted personalized recommender system [10].
However, some issues exist with the collaborative filtering approaches, such as data sparsity, cold-start and dimensionality. Such issues brought by big data have unenthusiastically affected the efficiency of conventional collaborative filtering-based recommendation techniques. The authors evaluate the conventional collaborative-filtering-based approaches and methodologies used in recommender systems. Authors have studied recent hybrid collaborative filtering-based recommendation techniques. The authors have included the latest hybrid memory-based and model-based collaborative filtering algorithms. At last, they discussed the potential impact that may improve the recommendation system and its future direction [11].
The recommendation system is based on collaborative filtering and knows or forecasts the customer choices or preferences for items by knowing past user experience, which may arrive from a group of customers who share the same ratings and have the same taste. In this paper, authors have explored various aspects of the collaborative filtering approach. The authors have categorized the collaborative filtering approach and shown the outcomes as a computed user–item similarity matrix. The authors wrote about the various challenges faced in collaborative filtering. The authors have collected ratings from the existing users to rate items and satisfy the user-items rating matrix with the given collaborative

filtering approach [12].
The main purpose of this paper is to represent a complete study in the field of collaborative filtering. The authors discussed different aspects of collaborative filtering, such as clustering, classification techniques, user-item similarity metrics, data fetching techniques, forecasting techniques and overall performance metrics. Authors reviewed various applications of collaborative filtering in various domains; even more than 150 research papers were reviewed and classified according to their area of collaborative filtering approach [13].
In this paper, the authors introduced a collaborative filtering approach, combining the advice, suggestions or recommendations of huge online communities. In this paper, the authors introduce the core concepts of collaborative filtering, with the main objective for customers of the adaptive World Wide Web, the algorithm used in collaborative filtering. This approach mainly identifies the rating metrics to evaluate the collaborative filtering techniques. Today internet allows us to go beyond easy word-to-mouth. The internet allows us to process these suggestions or recommendations in real life. The recommendation system determines not only what a community thinks of a product or user but also develops a personalized system to view the product using recommendations most appropriate for a customer or group of customers [14].
This paper uses a user model to form personalized recommendation systems. The authors introduce a special framework named Mahout which uses the approach of the Nave Bayes Classifier. In conclusion, in the collaborative filtering approach, the user model is an algorithm of the machine learning system. Machine learning is a system that works on a trained data set and concludes the outcome. In the age of information filtering, Although several machine learning algorithms are running on the Hadoop platform, they solve many practical problems and implement an effective and more personalized recommendation system for better customers. In online communities, the quality and speed of user search information are improved. Meanwhile, in an internet environment with huge data, the speed of information is improved, and the server load is reduced [15].
The collaborative-based filtering technique is the most widely accepted application of personalized recommendation systems. Although, due to some challenges, such as sparse data and cold, sparse issues of collaborative filtering techniques and the continuous growth of information in e-commerce databases, the e-commerce recommendation system deals with many issues. This paper has conducted many important investigation techniques and studies on the collaborative filtering approach. The authors proposed a modified collaborative filtering algorithm in this paper. This paper investigates an algorithm named community detection; basically, two community detection algorithms based upon a central node and k-based groups are implemented. At last, the authors choose user neighborhoods from the user network, which the user-item network anticipates. The main advantage of this approach is to reduce calculation time, the recommendation speed and the accuracy of the recommendation system. This paper is a right example of social networking and collaborative filtering techniques with increased performance of a recommendation system. The dataset has been driven from the MovieLens dataset. The authors discussed two important parameters, which are MAE and RMSE. In this paper, the outcomes show that the modified collaborative-based filtering algorithm is better than other collaborative-based approaches for specially MAE and RMSE performance [16].

Hybrid Filtering Techniques

In this paper, Sanya Sharma et al. discussed multiple aspects of hybrid-based filtering systems like machine learning, data mining and warehouse, interactive user interfaces, mathematical models, statistics, information filtering and decision support systems. These multiple disciplines contribute to the development of recommender systems. Now, several recommender systems algorithms are used for filtering information and providing users with suitable best options according to their requirements or searching information. In this paper, the authors discussed that the way people find goods or data is greatly affected by recommender systems. So, one can say that the recommendation system is a method to reduce the overloaded data. The authors discussed a new algorithm based on composite or hybrid search; it combines a few filtering techniques and presents more filtered data in the form of results [17].
Sanya Sharma et al. discussed the hybrid recommendation systems as combining the approach of two or more two recommendation approaches differently to help from their associating benefits. The authors wrote about the systematic literature review in this paper. This paper gives the position of the ability in hybrid approach-based recommendation systems in recent years. The authors address the most important issues available in the existing deep learning and recommendation approaches used to conquer them.
The authors also investigate the hybrid classes of each recommender system belonging to their domain. According to their findings, the most common hybrid collaborative filtering studies with other approaches are frequently biased. There are some problems like cold-start or data sparsity; these are two conventional and major issues being addressed in 30 and 32 studies each, while the concerned datasets for movie recommendation systems are immobile and widely used by many research scholars. In this paper, the authors discussed novel challenges, and contemporary issues, which were also recognized, such as responding to the discrepancy of customer perspective and evolving customer choices.
Vahidi Farashah et al. wrote that recommendation systems have been a vital field for computer science researchers. The authors discussed one major issue: Basket analysis for online users and recommending the most eligible product, such as a book, mobile phones, and movies, to new customers. After analysis, proving a favorite product, such as a movie, to the user will increase sales and improve the system. The authors proposed several techniques to analyze user baskets and offer suitable products to the customers. But each method has issues, such as lack of accuracy, mean access error, etc. This paper uses a user prediction-based method to meet the issues of other techniques. The authors proposed four steps

in this paper: (i) use the customer-based rating system i.e. all users are classified by spatial clustering method such as DB scan, and further make classifications for new customers using a deep neural network approach. (ii) Hybrid recommendation system combines content-based and collaborative filtering-based methods. Using these techniques, authors discussed the similarities between the products, and they are calculated based on a function which is a threshold value between the new customer and the customers in the selected or existing categories. (iii) After executing the improved algorithm on the existing data set to calculate the similarity metrics between new customers connected through the modified link. (iv) In this last step, the combined form of the collaborative-based filtering system's outcome and the modified algorithm has presented. The output shows that the modified algorithm's Mean Squared Error has decreased with comparing models like randomized algorithm decision-tree and Naïve-Bayes algorithms [18].
In this paper, Deepjyoti Roy et al. wrote that recommender systems are powerful tools for filtering information for online users. Recommendation systems are changing the habits of online customers and their needs. Although the latest recommendation systems are very efficient for filtering information, they suffer from several issues like data sparsity, user scalability, cod-start problems, etc. Many approaches are available for recommendation systems, so selecting an appropriate approach or algorithm becomes difficult while creating an application-based recommender system. Apart from all these things, each approach used in creating recommender systems has its characteristics, benefits and limitations. In this paper, the authors discussed various algorithms in hybrid recommendation systems, focusing on real-life applications such as book recommendations, song or music recommendations, and product recommendations [19].

Fatima Zohra Trabelsi et al. discussed hybrid recommendation systems. The recommender systems have become popular in various real-life areas, such as products, e-business, e-marketing, advertisements, social networking sites, user trust, etc. The category for recommendation systems is either content-based filtering or collaborative-based filtering approach, or hybrid-based filtering approach to suggest products to customers. However, each type of filtering approach has its advantages and disadvantages. In this research paper, the authors wrote about the outcome of recommendation systems and their supporting literature review. The main task of this paper is to recognize the various issues that the hybrid-based filtering approach tends to solve. The recommender systems usually need to consider important factors like customer service and satisfaction, the coverage area for the problem, accuracy, etc [20].
F.N. Alpaslan wrote about Content boosted collaborative filtering hybrid recommendation systems. Today, recommendation systems have changed the way people search for information, new products or people on social networking sites. The recommendation systems see the blueprint of the customer's or client's performance, suggestions, comments, reviews, etc. The technology behind the recommendation system has taken place for the past 10 to 15 years. The authors proposed a hybrid-based recommendation system for publishing or accessing research articles in this article. The hybrid recommendation approach combines content filtering and collaborative-based approaches. The hybrid approach is bottom to a top technique for identifying research articles. For example, customers can find their articles or blogs. The proposed system uses collaborative-based information filtering and contents-based information filtering approaches along with author names, submission dates of articles, the title of the research etc. The proposed system optimized the output for these approaches by using hybrid-based techniques such as customer-to-item techniques or item-to-item algorithms (which are used by amazon.com) for filtering the items for the customers. One major issue regarding such techniques is the cold start issue when sufficient information is unavailable or inadequate information exists in the data set. This paper eliminates the cold start problem for new products or customers from the existing recommender systems [21].

A. Tale et al. discussed a case study on a product recommendation system makes a decision strategy for the entire buyer under a highly complex or appropriate data environment recommender coined by the e-commerce builder as a systematic model to help clients or users search based on required information which relates to buyer's preferences. The recommender or suggestion provider model is defined as a supportive enhanced methodology for suggestions of the available client to form decisions easier for others when there are no adequate preferred choices and goods attribute understanding. The recommender model resolved issues with overloaded informational data that clients or users came by providing adapted low-stock content observed suggestions. Some implemented approaches for their use in modeled recommender systems to exploit collaborative filtering, content driven and hybrid approach [22].
A. J. Fernandez et al. discussed the recommendation system for component based applications such as a content-based Filtering is established and realized to build a database of preferred goods from their user or clients. Then, it matches clients with appropriate choices by evaluating the similarity between the user profiles and their choices for the known suggestions. Collaborative-based filtering approach offered by another buyer's classifying matched test to spawn their decision to suggest an item to the buyer. Collaborative suggestion provider recommender appreciated in many fields. An online community like Ringo formed a knowledge-driven information filtering model that works with Collaborative Filtering to client profiles based on their selected song album ratings. Amazon diversifies the suggestion model enhancement system using Collaborative Filtering to conquer scalable issues from collective production of goods similarity offline by goods matrix uses. The system suggested other goods similar to the given buyer's buying history [23].

5. Result and Discussion

The Matrix Factorization (MF) model will be implemented using state-of-the-art algorithms such as Singular Value Decomposition (SVD), Alternating Least Squares (ALS). These techniques will be used to learn the concealed features of customers and items based on their preferences in the user-item simulation matrix. One may also experiment with various regularization techniques, such as L1 and L2 regularization to prevent overfitting [24].

The Neural Network (NN) model will be implemented using Deep Learning (DL) frameworks such as TensorFlow or PyTorch. The input to the neural network will consist of customer and item features such as age, location, gender, and category. The network architecture will consist of multiple layers of fully connected neurons with non-linear activation functions such as sigmoid function. One may experiment with various network architectures such as Multilayer Perceptron (MLP), Convolution Neural Networks (CNNs) and Recurrent Neural Networks (RNNs).

Datasets

The quality of dataset is an important as the quantity of that dataset. According to the state of data science forum, data preparation is one of the most important tasks of machine learning algorithms. For this research work, three datasets have implemented. These datasets are already segregated and cleaned for machine learning algorithms. With these three datasets, the data for this research is more diverse. GroupLens (Movie Lens) data set has collected and available from the website (https://movielens.org). This entire data set describe about user preferences, users ratings as well as tagging activities from the given website.According to the state of data science forum, data preparation is one of the most important task of machine learning algorithms. For this research work, three datasets have implemented. These datasets are already segregated and cleaned for machine learning algorithms [25].

There are three important datasets to test the proposed algorithms performance in this work. The reason for taking multiple datasets is that it will cover all possible dependencies of dataset nature like baized, sparsity, etc. Datasets are as follows:

1. Hindi Movie Dataset.
2. Book Cross Dataset.
3. Movielens Dataset.

Movie Dataset is known as exponential growth in terms of volume of business and the global reach. Here, it could be of great commercial importance to develop a new user generated model which could predict the recommendation system and forecast demand for a new product.

During the last few decades, with the rise of Netflix, Amazon and other sources of web services, the recommendation systems have taken more and more places in the daily lives. Basically, the recommendation systems are machine learning algorithms aimed at suggesting relevant products, books, movies and many other things to users. The book crossing dataset is comprised of three important tables, like as:

1. BX- Users, this contains the information about users and some demographic data like location, age.
2. BX- Books, this contains the book information like book-title, book-author, year of publication, publisher.
3. BX- Book- Ratings, this contains all of the book rating information.

6. Findings

In this research paper, a hybrid recommendation system is used to improve the accuracy and coverage of suggestions by combining two important algorithms that is Matrix Factorization with Neural Networks. The proposed method is assessed using a variety of datasets, and the results demonstrate that, in terms of Mean Absolute Error (MAE), Root Mean Squared Error (RMSE) and coverage, it performs better than other progressive recommendation algorithms.

7. Conclusion

Neural Networks (NN) and Deep Learning (DL) have been popular in various disciplines in recent years, and it appears they can also be used to solve recommendation system challenges. One advantage of Deep Learning, similar to Matrix Factorization (MF), is the capacity to infer hidden properties. On the other hand, deep learning may compensate for some of matrix factorization's shortcomings, such as the inability to include time in the model - something ordinary matrix factorization isn't built for.Future work can focus on incorporating user feedback, exploring multi-task learning and incorporating temporal dynamics, investigating explainability, and evaluating real-world deployment.

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