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## Various Methods of Using Content-Based Filtering Algorithm for Recommender Systems

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**ABSTRACT:** Recommender systems play an active role in many applications for generating personalized recommendations to the customers. In that the content-based filtering recommend items based on the content analysis and the user profile and the collaborative filtering recommend items based on the user ratings. This paper presents a survey on various ways in which the content-based filtering algorithms optimized for effective recommendations to the customers. The content-based filtering algorithm predicts the suggestions for the user according to the user's interest.

**KEYWORDS:** Recommender System; Content-based Filtering; Collaborative Filtering.

### I. INTRODUCTION

The concept of Recommender Systems or Recommender Engine rise out of the idea of information reuse and steady preferences. It is an idea that doesn't begin with computers and technology. It is an idea that we can find in ants, and all sorts of other creatures. For example, ants running around our house often follow a line from the ants that went before and find food. That is because ants have the ability to leave markers for other ants, thus helping other ants for food, survive and breeding. This is a system that relates in research as social navigation, following the footmark of others to find what we want, like we use social navigation if we are in a place where we don't know our way. This concept of social navigation is the idea of social information reuse. Recommendation systems or recommendation engine can be defined as the systems to select similar things whenever the user likes something, for example, suggesting movies, songs, products or friends in social media. These days there are so many applications are available in smart phones which recommend other applications to the user. This is one of the recent developments in the field of recommender systems. The recommender systems are broadly classified into three, namely collaborative filtering, content- based filtering and hybrid filtering. This survey paper mainly focuses on content-based filtering algorithms.

### II. RELATED WORK

Dima S. Mahmoud in [1] researched on how the content based filtering can suggest a list of items to the users from huge amount of data. They enhanced the content based filtering algorithm by using artificial bee colony optimization in order to look over a huge data set and recommend a list of items to the users.

Y. F. Zhao in [2] used the content based technology and k-nearest neighbour in recommendation systems for effective traffic signal control in urban traffic. For this they first found the similar traffic conditions and then a matching degree has been analysed between the current traffic conditions. Thus various timing plans are being predicted.

Prem Melville in [3] presented a content boosted collaborative filtering approach in which it used a content based predictor for inflating the user data and delivered personalized suggestion using collaborative filtering. It differs from the pure content based and collaborative filtering approach.

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N.Thilagavathi in [4] designed a systems to filter the unwanted messages in online social networks. They also enhanced the work by using flexible rule based system to allow the user to have direct control over the messages posted on their pages or walls. Here the used machine based learning based on soft classifier for facilitating the content based filtering.

AnandShankerTewari in [5] presented a recommendation systems for books combining the features of content based filtering, collaborative filtering and association rule mining techniques. Nowa-days heavy competition can be seen among the online book selling websites and the recommender systems plays a vital role in increasing their profit margin and also for retaining the buyers.

The problems related to insufficient information in mobile content recommendation systems affected the performance of the systems for predicting the items for user. But multi-level targeting classification association rule technique addressed this problem. Here Worapat Paireekrenl in [6] proposed an improved multi-level targeting classification association rule with content based filtering and user profile for providing better recommendations to users.

FatemehAkbari in [7] presented a recommender system for suggesting friends in online social networks. The used graph based topology and artificial bee colony technique for recommendation. They generated subgraphs and computed four parameters for suggesting new links. Finally artificial bee colony is used for optimization of weights of each parameter.

Kejun Dong in [8] concentrated on the recommendation of microbloggers for web-based communities. This recommendation system used a hybrid content based filtering approach which used top-model clustering and TF-IDF cosine similarity. This enabled the interaction between a scientific research community and public social media.

One of the classical and effective algorithms in recommender systems for personalized recommendations are collaborative filtering. But the major demerit of this kind of filtering method is that they suffer from sparse user rating record matrix problem. So Jiaqi Fan in [9] proposed an algorithm which integrated content-based recommendation algorithm and user activity level.

Pasquale Lops in [10] presented a content based recommender system which integrated user- generated content with semantic analysis. It was named as FIRSt system. By applying machine learning techniques, FIRSt enables the content-based recommender to infer user interests.

Mohammed Nazimuddin in [11] developed a hybrid recommender system incorporating the components from collaborative filtering and content-based filtering. They included a diverse item selection algorithm which used a diversity matrix for selecting the dis-similar items among the recommended items from collaborative filtering, which together with the inputs are fed to content based filtering algorithm.

A new algorithm for recommender systems was proposed by Hui Li in [12] using Hidden Markov Model. They combined classical content-based filtering algorithm and the probabilistic model. The match between the user model and item of interest was done by the Hidden Markov Model of recommended items.

Leo Iaquina in [13] implemented a hybrid recommender system by combining the content based filtering algorithm and serendipity heuristics. The over-specialization problem of the content based filtering approach was alleviated by this work. The system designed here motivated the users by promoting serendipitous suggestions.

Kazuhiro Iwahama in [14] proposed a content based filtering system which targeted music data in MIDI format and a filtering method based on the featuring parameters. The system extracts feature parameters from both of music data that the user has already rated. Then the system compares both the feature parameters by using classification algorithm and thus the system recommends music data that the user will like. The system will reduce the users' burden in acquiring music data.

Finding information on a large web site can be a difficult and time-consuming process. So Robin van Meteren in [15] described a recommender system PRES (Personalized Recommender System) that used content-based filtering techniques to suggest small articles about home improvements. A domain such as this implicates that the user model has to be very dynamic and learned from positive feedback only.

Recommender systems apply knowledge discovery techniques to help people find what they really want. Chen Jian in [16] proposed a simple efficient indexing structure and a heuristic information retrieval technique algorithm for

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searching reverse k nearest neighbour in high dimensional dataset. The above mentioned methods are discussed in detail below.

### III. DETAILED REVIEW

Dima S. Mahmoud in [1] used the method of real bee life in enhancing the content based filtering algorithm for recommending the users with items from a huge amount of data. In real bee life, there are three types of bees namely, worker bees, onlooker bees and scout bees. Each of these bees have their own significant roles to be done. The worker bees find the food sources and return to their hive and perform a waggle dance, which describes the evaluation of their findings and the geographic location of the food source. The onlooker bees watch this dance and choose the food source. Then they search in the neighbourhood of that location for finding better food sources. The scout bees are the worker bees of any un-visited food sources. This natural activities of bee life is mapped to Artificial Bee Colony optimization algorithm. The work in [1] considered only the filtering component of the content based filtering process as the optimization problem. To address this problem they have tuned the artificial bee colony technique to it. They examined the scenario of a book store and obtained a list of recommendations from the given book store matching the interests. The merit of this method is that they recommended more than one item based on the interest of the users. The demerit is that the description of data in the item profile should be well defined.

All over the world have been attracted by the traffic congestions during the past few decades as it about the people's livelihood. For solving the urban traffic signal problems, traffic signal control is an effective method. It provides the appropriate signal control plans for various traffic conditions. [2] used the recommendation technology for solving the various traffic problems. Here, they applied content based recommendation method was used to find the most similar road conditions and recommend the best timing plans according to the current road conditions.

The data rate on the internet is rapidly growing so that it becomes difficult to abstract useful information from huge volume of data. Collaborative filtering is one of the widely used approach for recommendations. But the main disadvantage of the collaborative filtering is the sparse user rating record matrix. To enhance the performance of collaborative filtering approach, [3] implemented a method of padding the user-item matrix by filling all the missing user ratings values with an average rating. To predict the missing value in the user-item matrix, content based recommendation algorithm is used. A user activity is defined which enhance the predictive accuracy. User activity defines the frequency of comments on items of certain type. It reflects the user preference to some extent for some specific type of items. By filling the missing ratings in the matrix, the recommendations can be produced to the users using user-based collaborative filtering. The merit of this method is that it avoids cold start problem to some extent. But it is impossible for a user to rate all the items with some value.

In online social networking managing the messages that are posted on a user's wall is considered as one of the basic issues. These networks provide only a minimal assistance to avoid the unwanted messages to be posted on a wall. Now-a-days social networking sites are the familiar interactive medium to share or exchange individual information. Text, audio, video contents are being exchanged every day. This is one of the advancement in computing and communication technologies which enables the common people to share information in innovative ways. But the problem the users face is that, they are overwhelmed with large amount of data. One of the methods to provide appropriate information to users is information filtering. It provides the users with classification mechanisms to avoid unnecessary information. Filtered wall architecture is used to support the content based filtering in online social network. To categorize the incoming messages text mining techniques are used. [4] proposed filtered wall which is an automated system for filtering the unwanted messages from user walls. This system used machine learning based text categorization techniques.

Book selling websites are abundantly available in internet now-a-days. Many of these websites are having their own private recommendation system to suggest the books for their users. The method in [5] proposed a book recommendation system by combining the features of association rule mining, collaborative filtering and content based filtering techniques. The system first finds out the category of books which the buyer bought earlier. Then content based filtering is performed on this category to find the similar books to user's interest. Next item-based collaborative filtering is carried out on the result of content-based filtering output to list out the books in the descending order. Then

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association rule mining is applied on the book transaction database in order to list out the books that the user can buy afterward. Final recommendation are done based on these steps. One thing to be noted is that all these actions are performed when the buyer is offline and the results are stores in the buyers web profile. The merit of this system is that performance problems are less since the recommendations are built offline. But this technique considers only content and quality parameters of the book can be taken as the demerit of this system.

[6] demonstrated the user interaction with the recommendation systems and the usage of content based filtering and multilevel targeting classification association rule (MTCAR) by incorporating content based technique to find relevant content items on a mobile content recommendation system. For this method, it first selected the users who interacts with a recommender system and rate the content items as a mixture of low and high ratings. Next these users are clustered according to their ratings. The top rated content items are considered to be the popular items. But the individual ratings for the group's top three content items may differ and it may affect the recommendation quality. For this multi-level targeting classification association rule is implemented in the client side. MTCAR skips the user classification phase and it proceeds for finding the relevant items for recommendations.

One of the fundamental problems found in online social networks like facebook, twitter, linkedin etc are friend recommendation. It aims to suggest new links for each user in the network which probabilistically be accepted. In most of the networks Friend-Of-Friends approach was used. [7] proposed a method for friend recommendation using artificial bee colony technique. Artificial bee colony is a swarm intelligence based technique [1]. This technique made the use of topological features of the social networks. For each user some friends are recommended. For this the user first composes a sub-graph and all the other users are separated by a three degree from the root user. Then for each candidate node, four parameters are calculated within the composed subgraph. Finally the candidate nodes are sorted according to ABC optimization and the root user is suggested with new links for optimizing the weights of four parameters. It generated the optimized formula for the ranking of the new links. Filtering and ordering were the essential process considered here. Filtering is done by considering Friends-Of-Friends nodes for each of the nodes and it limits the recommendation candidates. Ordering puts the most relevant nodes in the top of the recommendation list. The merit of this technique is that artificial bee colony is used for optimization for better friend recommendation. But the demerit is that one should have a good knowledge about topology and the structure of the social networks.

Microblogs are becoming a huge internet resource repository in the past few years and these microblogging systems are produced by hundreds of millions of people. Microblogs are especially very popular in china and have a big leap. [8] enables the interaction between the scientific research community and public social media by recommending microbloggers to the community on a specific topic. The proposed methodology in [8] has three phases namely top-model filtering, space vector model and TF-IDF weights and cosine similarity calculation. Top-model filtering clusters the microbloggers by traditional Latent Dirichlet Allocation (LDA) based model. It is a generative probabilistic model for discrete data collection. Then vector space models for the documents are constructed in the next phase. TF-IDF is used to calculate the weights of terms which is based on the ranking of the words. In the last phase, cosine similarity is considered to compare the documents in the text mining. The merit of this method may be the recommendation of microbloggers using hybrid content-based filtering is reliable and effective. But the demerit is that the user descriptions, tags etc from the user profile are not used here.

Information filtering and retrieval research are used to derive the content based filtering algorithm. In [9] the authors have proposed a Hidden Markov Model for recommending the items which match the interest of the user. It is a probabilistic model such that it consists of a set of states and output symbols. The states can be transformed from one state to another with so many output symbols. This Hidden Markov Model generates different sequences of output in different probabilities. The content based filtering algorithm using HMM is based on the equal length sequences of initial data. The hamming distance between the data are calculated. Then as a similarity metrics K-means is used with hamming distance to cluster the sequences of data. Thus k initial clusters are built. The Hidden Markov Model for each of these clusters are trained by implementing Forward- Backward algorithm and thus k HMMs are produced. Then the probabilities of each sequence are reallocated to the HMM. As the probability increases, the distance between the sequences and HMM also increases. The merit of this method is that the algorithm is more effective for the personalized recommendation when compared to Vector Space Model algorithm. The demerits are, this algorithm cannot be used for all-purpose recommendation algorithm and also the precision is less when compared to others.

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Information filtering techniques are used for the removal of non-relevant information or content according to the interest of the users. The user information are previously collected and they are stored in a user profile. Content based filtering technique analyse these information based on its features. Folksonomy is the taxonomy generated by the users which categorizes the interest of users with tags. Folksonomy is one of the forms of user generated contents (UGC). [10] proposed the method of learning the user profile on static contents and user generated contents and they used semantic analysis of the contents are done to overcome the limitations of keyword based approaches. They adopted knowlwdge bases for the annotation of items and profile representation of the user information needs. The merit of this system is that static and user generated contents are preventively analyzed and also the limitations of keyword based approaches are rectified.

[11] presented an enhanced method for content based filtering with diverse collaborative approach. It used a diverse item selection algorithm which used a diversity matrix. Architecture is shown below. The content database contains the information about movies, actors, directors etc. collaborative filtering calculates the similarity between the users by taking the users rating. It gives the suggestions to the neighbours. Then diverse-item selection algorithm is used to select some 'k' items among the items recommended by collaborative filtering. The content based filtering then takes the active users ratings and 'k' selected ratings from diverse item selection process as the input to the process. It obtains the relevant information and follows a scoring mechanism in the content attributes. Finally, by using this diverse collaborative prediction, recommendation for the new item is made. The merit of this system was that the limitations of ordinary content-based filtering was rectified by using diverse collaborative prediction and there by overspecialization problem also. But there should be a minimum number of active user ratings to carry out this algorithm can be considered as one of the demerits.

The common issue that the society faces is the information overload problem. Information filtering and reuse is one of the techniques that overcome this problem by providing the user with the most relevant information. For providing the user with customized information, recommendation system uses information filtering technique. In recommender system the content based filtering approach has the problem of over-specialization, in which the system only recommend items based on a user's profile. This prevents serendipitous happening or surprising suggestions for a user that he/she might not have discovered. So the authors in [12] introduced serendipity to the content based filtering system. The content analyzer analyses the documents and identify the relevant concepts of the content. It is a repository of these relevant concepts of the content. The profile learner implemented a supervised learning technique for the probabilistic model of the user's interest. This learner model is a schematic profile which represented the concepts. The recommender module matches the concepts with the user profile and recommends relevant documents. The module discovers the serendipitous which has been included in this model. The merit of this system is that serendipitous suggestions are given to user. The demerit is rating interpretation problem, in which it should be in homogeneous nature with other rating. Also the programming of the serendipity has not been studied deeply anywhere.

In [13] they demonstrated a hybrid approach for movie recommendation.in content-boosted collaborative filtering, pseudo rating for every user is created in the database. All the user ratings are put together to form am matrix. Then collaborative filtering is performed based on this matrix. The similarity factor between the user are calculated based on a correlation coefficient called Pearson correlation coefficient. The merit of this system was that the sparsity problem was eliminated by providing pseud user ratings. The demerit was that the ratings are represented on a linear scale and the numerical predictions cannot ne produced directly.

With the development of the Internet, the quantity of information is explosively increasing. In this situation, users need to acquire appropriate information from the huge network of information. [14] constructed a content-based filtering system for music data. The target data of the system were not written in MP3 or RealPlayer which record audio wave but are written in MIDI data which record note data. The user rates several music data from the viewpoint that whether the user prefers them or not. The system extracts feature parameters from the rated music data. Feature parameters consist of attribute and attribute value and represent the characteristics of music data. The system builds a user profile, which represents the user's preference about music, based on the extracted feature parameters. The system extracts feature parameters from target music data and compares those feature parameters with the user profile. From the result of the comparison, the system selects music data that the user will like, and recommends the music data.

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[15] helped users find the information that is in accordance with their interests. Recommender systems can improve a web site for individual users by dynamically adding hyperlinks. In this paper the recommender system PRES is introduced. PRES creates dynamic hyperlinks for a web site that contains a collection of advises about do it yourself home improvement. The purpose of these dynamic hyperlinks is to make it easier for a user to find interesting items and thus improving the interaction between the system and the user. A user profile is learned from feedback provided by the user. The recommender system compares the user profile with the documents in the collection. The documents are then ranked on the basis of certain criteria such as similarity, novelty, proximity and relevancy and the best ranked documents appear as hyperlinks on the current web page.

With the rapid development of e-Commerce and its increased popularity in ease-use tools, the world is becoming more and more a global marketplace. But the amazing number of news and other information of products in e-Commerce sites make us feel it is necessary to find some new technologies that can dramatically reduce the useless information and help us sift through all the available information to find which is most valuable to us. [16] presented a new query mechanism which is explored to automatically recommend the new items to those users that seem to have the similar tastes or interests matching with the content features of this item. In this automatic recommender system, the users are divided into groups who appear to have similar preferences according they accessed similar content in Internet. Semantic content features of a new item will be extracted to match the format of feature vector database. After adding it to database, we provide an efficient way to calculate and retrieval the similarities distances between the feature vectors of new item and users clusters. Actually, it is a process to find "influential sets" of new item, which can be accomplished by a reverse  $k$  nearest neighbour query. Finally, this item will be recommended to these groups of users.

## IV. EXPERIMENTAL RESULTS

The previous sections mentioned various methods of using the content based filtering algorithms for recommender systems. This section classifies some of the selected methods with its merits and demerits.

| Sno | Title  | Method   | Merit   | Demerit  |
|-----|--|--|---|--|
| 1.  | Enhanced content based filtering algorithm using Artificial Bee Colony optimization              | Used artificial bee colony technique to optimize content based filtering algorithm   | Recommended more than one item based on the interest of the users | Description of data in the item profile should be well defined                       |
| 2.  | An improved collaborative filtering algorithm combining content-based algorithm and userActivity | Integrated content-based recommendation algorithm and user activity level            | Avoids cold start problem to some extent                          | Impossible for a user to rate all the items with some value.                         |
| 3.  | Graph-based Friend Recommendation in Social Networks using Artificial Bee Colony                 | Used graph based topology and artificial bee colony technique for recommendation     | ABC is used for optimization for better friend recommendation.    | Good knowledge about topology and the structure of the social networks is essential. |
| 4.  | Content based filtering recommendation algorithm using hmm                                       | Combined classical content-based filtering algorithm and the probabilistic model for | Algorithm is more effective for the personalized recommendation   | Algorithm cannot be used for all-purpose recommendation                              |

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|    |   | new recommendation system  | when compared to vector space model algorithm                                | algorithm and also the precision is less when compared to others.  |
| 5. | Introducing serendipity in a content based recommender system                                   | Implemented a hybrid recommender system by combining content based filtering algorithm and serendipity heuristics              | Serendipitous suggestions are given to user                                  | Rating interpretation problem, Also programming of the serendipity has not been studied deeply anywhere. |
| 6. | Content-boosted collaborative filtering for improved recommendations                            | Used a content based predictor for inflating the user data and delivered personalized suggestion using collaborative filtering | The sparsity problem has been eliminated by providing the pseudo user rating | Ratings are represented on a linear scale and the numerical predictions cannot be produced directly      |
| 7. | Book Recommendation System Based on Combine Features of CBF, CF, ARM                            | Combined features of content based filtering, collaborative filtering and association rule mining techniques                   | Performance problems are less since the recommendations are built offline.   | considers only content and quality parameters of the book  |
| 8. | A Hybrid Content-based Filtering Approach: Recommending Microbloggers for Web-based Communities | Used top-model clustering and TF-IDF cosine similarity   | Reliable and effective.  | User descriptions, tags from the user profile are not used   |

The above table illustrates the method, merits and demerits of some of the technologies developed using recommender systems. Each method has its own advantages and disadvantages. By considering the above table some objectives driven are content based and collaborative filtering algorithms can be enhanced by using the Artificial bee colony optimization and Ant colony optimization technologies.

### V. CONCLUSION

Information overload is a major problem as the internet is rapidly developing. The efficiency of the information filtering algorithms is of primary importance for providing better personalized recommendations for the user. The work here investigated different methods to enhance the performance of the content-based and collaborative filtering methods in Recommender Systems. All the methods presented above have their own merits and demerits. So as a future enhancement all the gaps of these methods are considered together to suggest a new algorithm for a better recommendation system.

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