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Recommendation Systems : A Detailed Review

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Abstract: ***We are in the midst of a renaissance right now. The data added in the past two years on the web is nearly double the data added in the whole human history. This excess-of-choice paradox has led to the dire need of certainty which can be achieved only by the usage of appropriate recommendation systems. At root, such systems stand upon simple factors like: the previous search details of the customer, the contents loaded in their virtual wish-lists and shopping carts, rated or liked items and what other users have rated and bought. However, what keeps them varied in terms of preference on a general basis is the data filtering approach used, namely: collaborative filtering, content based filtering, hybrid filtering and demographic filtering. Considering the fact that these systems hold a significant drive to increase the company's revenue as well as engagement over the web, it wouldn't be wrong to say that the choice of the right system to use is highly momentous. Thus, this paper attempts to clear the aura of confusion regarding the benefits and detriments of employing these systems and hence, helps in choosing the right system.***

Keywords: Demographic, Recommendation, Filtering, Collaborative, Utility, Context.

I. INTRODUCTION

We are living in a world that's ruled by data pouring in from all directions through papers, reviews, blogs and the other sources of information on the World Wide Web. It has been noticed that the number of users of internet have increased tremendously in the past few years crossing almost a 7 billion mark. However, this drastic increase in the population over the web has opened the doors for insurmountable confusion for the users when it comes to choosing one among the abundance choices.

This is where recommender systems jump in to help. They use machine learning techniques to go over all our options, learn what we like and recommend the best option for us – Amazon recommends products we would like, Google recommends search results we would like, Facebook recommends friends we would like, almost every service does it nowadays.

A recommender system, thus, can be defined as a very prominent subclass of information filtering systems that attempts to predict the accurate preference of the customer in terms of items being considered. However, what separates these systems from the normally used search-engines is its ability to sort out the "useful as well as interesting" entities among the search results. The vivid approaches for this process of recommendations are: content-based, collaborative-based and hybrid. These filtering based methodologies can either be used as a combination or individually, depending upon the data in hand. The following sections identify and explain these approaches in detail.

II. RECOMMENDATION METHODOLOGIES

The recommendation methodologies are basically algorithms that tend to forecast the target user's choice out of a huge collection of items even before the user gets to see all the available items. This discussion is based mainly on the data, rather than the user. Hence, it is the data source that the sits upon that will be studied more than the user's interaction with the system. So, the system majorly focuses on -

1) Input Data The user's choice of information that he/she asks the recommender to look for;

2) Background Data: As the name indicates, this comprises of the details that the system possesses before any recommendations;

3) Technique: The medium of combining both the above mentioned types of data and hence, reach a prediction to make.

Recommendation techniques are broadly categorized into two sub-categories, namely – personalized approach and non-personalized approach of recommendation. While the personalized approach prefers using the user's personalized information for the predicting process, the non-personalized approach opts for simpler means by simply suggesting using non-personalized factors such as popularity or recently-added. However, since the user's choices are not considered, the quality of recommendations are degraded as well, like for example, a book shop would recommend the same book to everyone. [1]

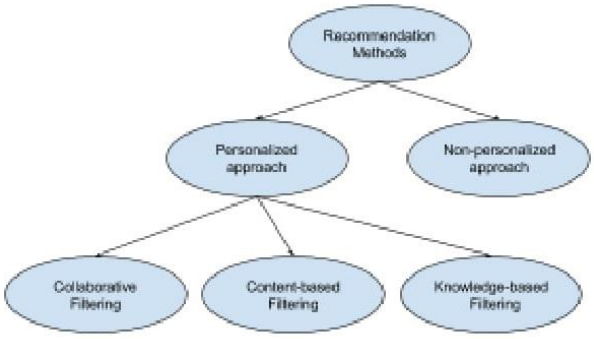

Fig. 1. Categorization of Recommendation Methodologies

Collaborative Based Recommendation Systems: This system maps the similarity factors between the items

and users and hence, suggests items to users on the basis of the choices of similar users. This approach can further be classified into two subtypes, namely – Model-based collaborative filtering and Neighbourhood based collaborative filtering [10] [15].

Model-Based Collaborative Filtering: This approach recommends the usage of the parameters of statistical models to be able to suggest user-ratings.

Neighbourhood-Based Collaborative Filtering: Here, user-details are analysed and a subset of users is chosen on the basis of their similarity to the target user and predictions are made depending upon the weighted combination of their ratings.

Content-Based Recommendation Systems: As the name indicates, these systems study the description section of every item and try to categorize the items based on it [4]. For example, if a Spotify user has been listening to Hip-hop music for a while, then the upcoming recommendations are more likely to be of 'hip-hop' genre.

Knowledge-Based Recommendation Systems: These systems have functional knowledge, i.e., they know the exact reason as to why the target user might require a specific item. Hence, they provide suggestions on the basis of interferences about a user's needs and preferences [16].

III. DATA-HUBS OF RECOMMENDERS

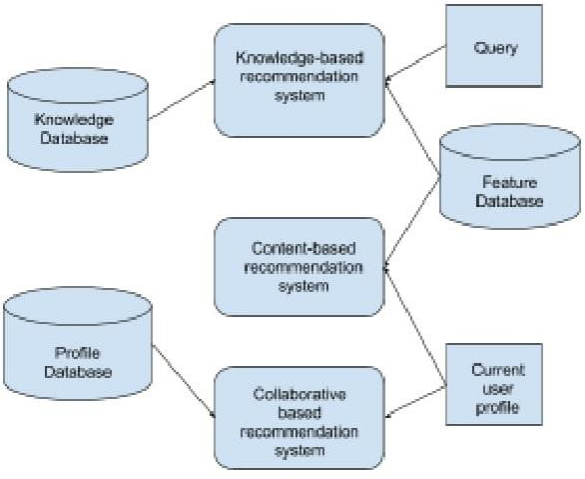

Fig. 2. Knowledge Acquisition in Recommendation Systems

The above figure represents the working of the collaborative approach based recommendation system appropriately. It compares and contrasts the target user's profile with a whole database of profiles of other users and builds recommendations based upon these comparisons. Content-based approach using systems, on the other hand, studies both the target user's profile as well as the database comprising the feature knowledge and finds the object ratings performed by the user and uses this newly acquired knowledge to build its recommendations. Whereas, the knowledge based recommender prefers using the query to enable predictions depending upon inferences regarding the user's requirements as well as choices [11].

IV. CONTRASTING RECOMMENDATION METHODOLOGIES

The following table briefly contrasts the recommendation algorithms that we have discussed till now by pointing out their supremacies and pitfalls. Unfortunately, both content-based and collaborative approaches suffer from ramp-up issue. This refers to the situation where the casual customers stay devoid of complete content-based and collaborative recommendations [5].

Methodologies	Merits	Demerits
Content-based filtering based recommendations	1) Domain knowledge is not necessary 2) Implicit feedback is enough.	1) Plasticity versus stability issue. 2) New user ramp-up issue
Collaborative filtering based recommendations	1) Implicit feedback is adequate 2) Domain knowledge not necessary 3) Identifies genre niches	1) New item ramp-up issue 2) Plasticity versus stability problem. 3) New user ramp-up issue
Knowledge-based filtering based recommendations	1) Ramp-up isn't needed 2) Mapping user's requirements with the available products Is an available option.	1) Knowledge engineering is a must here.

V. A FEW OTHER METHODOLOGIES

Context Based Recommenders: look for items that match the user's current context. This allows them to be more flexible and adaptive to current user needs than methods that ignore context (essentially giving the same weight to all of the user's history). Therefore, the algorithms based upon context hold higher chances of

presenting a recommendation that will be appreciated at that particular moment by the user.

Utility Based Recommendation Providing Systems: function by clustering customer entities depending upon the estimation of the services the article is capable of providing to the buyer.

Demographic Recommender Systems: on the other hand, sort customers and make predictions based upon their demographic classes [9].

VI. PROMINENT RECOMMENDERS

These are a few well-known online business firms which employ recommendation systems to enhance the quality and productivity of their websites [3] [2].

A. Levis:

This infamous clothing manufacturing firm employs Style Finder recommendation algorithm to enhance its ratings as well as revenue. The Style Finder enables the provision of recommendations on various items of Levi's clothing. Initially, the customer is supposed to inform the system about his/her gender, following which a selection of at least four subclasses each are done from the categories of – fun , looks and music. This is done by providing a rating value on a 7-grade scale ranging between 'love it' and 'leave it'. The option of selecting 'no opinion' is also available. Once this whole process is completed, the 'get recommendations' button may be selected.

B. Netflix:

Netflix has always been the one to set standards when it comes to discovering new content because the entire market of digital consumption is majorly affected by on-demand streaming video for consumption of data. This company has worked hard to make sure that its recommendation algorithms accentuate as much of its content library as possible. The results of the efforts put in by the recommender algorithms are highlighted through the reduced churn and increased viewership. Netflix's recommendation engine tuned for hyper-specific categorization, can match tiles to the exact people who would be interested in them.

C. Amazon:

Most of Amazon's phenomenal revenue growth has been built on overwhelming techniques of integrating recommendations across the buying experience -- from product discovery to checkout. Amazon is able to achieve a high level of customer relevance though algorithms based on a process called item-to-item collaborative filtering. A few sections on Amazon that represent recommendations are -

People who bought this also bought: This section comprises of items that possess similar qualities like the item currently being considered by the user.

Amazon.com delivers: This section provides a whole list of categories to check or uncheck for the users depending upon their requirements. The facility of providing email notifications to subscribers regarding latest recommendations.

D. Moviefinder:

This website's *Matchmaker algorithm* facilitates the locating and selecting of movies with some similarity quotient with the target movie like – theme, genre, cast or mood. The user is supposed to click on the Matchmaker icon on the information page of the movie to avail a list of recommended movies as well as links to movies that share sort of similarity like same director, actors, etc.

E. eBay:

eBay flaunts a feedback profile feature on its website which enables contribution from sellers as well as buyers to feedback profiles of other users with whom they have traded earlier. This feedback comprises of both specific suggestions as well as satisfaction rating about the services provided by the other customer.

VII. LITERATURE REVIEW

It all began back in the year 2001 when J. Ben Schafer analyzed how the work done by recommendation systems enhance the revenue of E-commerce related websites on the web and brought to light the then-condition of recommendation systems being used in several leading sites of the market in his paper "E-Commerce Recommendation Applications". This analysis was further used to create a proper classification of these systems and the terminology of the process of recommending which included vivid concepts like the knowledge used up from the database, input taken from the users and the representation tactics and personalization limits of the hence produced recommendations [2].

Later on in 2002, author Robin Burke enlisted a whole variety of methodologies that had been proposed till date for availing recommendation, like collaborative filtering of data, knowledge based filtering of data, hybrid approach, etc, in his paper - "Hybrid Recommender Systems: Survey and Experiments". Not only did this paper study and explain the possible means to achieve an efficient hybrid recommendation system but also created an absolutely new hybrid recommender christened as Entrée C which recommends suitable restaurants by using a combination of both - collaborative and knowledge based information filtering techniques [5] .

The paper "Evaluating collaborative filtering recommender systems" published in 2004 by Jonathan L. Herlocker helped by providing a brief review of the points to kept in mind while appraising recommendation systems that employ collaborative

filtering based information filtering, like the medium of estimation of quality of forecasting, the data being used for the process, available types of analysis, the exact tasks done by the user that are being checked upon and also the whole process of customer- based evaluation [13].

K S Esmaili pointed out that the Weblogs, in spite of being one of the most fundamental components of the World Wide Web face difficulties in exploring and coming up with relevant-enough blogs, through the paper "Comparing Performance of recommendation Technique in the Blogshere" in 2006. This paper not only explained the cause for information overload issues, but also presented the design of a novel weblog recommender system based on link-structure of weblog graph, provided the fact that the links joining these weblogs have been treated as some sort of rating. The methods, on the other and, have been implemented on a real dataset [7].

The year 2007's highlight was the paper "Content Based Recommendation System" by Michael J Pazzani that drew attention towards content-based recommender systems which use the description section of the item and the user's profile to figure out his/her interests and based upon this, recommend items to users [4].

VIII. HYBRID RECOMMENDATION SYSTEMS

As the name indicates, hybrid systems avail recommendations by combining several recommending techniques to enhance the quality of the recommendations as well as the efficiency of the system. The goal is to overcome the flaws of individual techniques of recommendations by combining them with other techniques and hence, create a flawless model which can give an appreciable estimate of efficiency. One of the best examples of hybrid systems stays Netflix. The accuracy of predictions related to how much a recommended movie would be enjoyed by the target user was sought to be improved by declaring the Netflix Prize. However, "BellKor's Pragmatic Chaos" [8] won the $1M Grand Prize on September 21, 2009. Netflix faced a lot of trouble when privacy issues arose around the datasets it offered for the competition. Two researchers of the University of Texas managed to identify individual users by matching the data sets and the Internet Movie Database's film ratings, even after Netflix's anonymizing the datasets to preserve customer privacy, in 2007. Due to this, an anonymous Netflix user sued Netflix in Doe v. Netflix in December 2009, with the allegation that the U.S fair trade laws as well as the Video Privacy Protection Act had been violated by the release of the datasets. Needless to say, this lead to the second Netflix Prize Competition being cancelled in 2010 [14].

Usually the classification of the hybrid systems completely depends on the input/output expressions and hierarchy of the system built. There are a several types of hybrid systems [5].

A. Feature Augmentation:

As the term 'augmentation' indicates in the name, this method of hybrid recommendation uses one technique to avail a rating or classification of an item and the result obtained from this step is then provided to the next recommendation algorithm in store and this goes on till all the recommending strategies have contributed appropriately.

B. Cascade:

Contrary to the other hybrid recommender algorithms, this methodology suggests to employ a technique to avail a rugged ranking of candidates, followed by which another technique is used to refine the recommendation from this pool of chosen nominees.

This process permits the system to avoid using the follow-up, lower-priority step in case of items that are already well-separated by the first, whereas, those which are already sufficiently poorly-rated will never be included as a part of recommendations.

C. Feature Combination:

Feature combination is yet another technique to enable the mix-match of content-based and collaborative information filtering techniques. It treats collaborative information as merely an extra feature of the data associated with each sample and uses content-based techniques over this augmented data set. This type of hybrid approach enables the consideration of collaborative data by the system without actually relying upon it, This, in turn,helps in reducing the sensitivity of the system to the total number of customers who have rated a particular item.

D. Mixed:

Everytime a requirement for massive number of recommendations is faced, it is advised to choose a mixed hybrid system, since it manages to present recommendations from more than one technique simultaneously. However, unfortunately, cold start problem of both the kinds, namely - new item and new user, can not be avoided while using this system as both collaborative as well as content-based information filtering approach, require some historical data to get set to work.

E. Switching:

Item-level sensitivity is built into the hybridization strategy in case of the switching hybrid recommendation system. This system constantly switches between recommendation algorithms, introducing a whole new level of additional complexity to the recommendation process since determining the criteria used for switching is not easy and this introduces another level of parameterization. The

system stays sensitive to the strengths and weaknesses of its constituent recommenders and this can be considered as one of the several benefits of using this system.

F. Weighted:

Weight refers to score. So, a weighted recommender system is the type of recommender system which prefers to compute the score of likeability of a recommended item using all the embedded recommendation algorithms in the system being considered. The best part of using this system is its simplicity which comes from the fact that all of the system's abilities have been brought to bear on the recommendation process in a straightforward manner. Also, it has been noticed that it is easy to perform post-hoc credit assignment and adjust the hybrid accordingly.

IX. CONCLUSION

Every single recommendation system that has been used till date employs either individual or a combination of pre-defined information filtering approaches, namely - collaborative, content-based, knowledge-based, utility-based and demographic. Relentless efforts have been put in the process of studying and building of vivid types of hybridised recommender approaches, like those talked about in this paper, namely - feature augmentation, feature combination, switching, mixed and weighted. A contrast between various techniques has also been drawn through the merits and demerits part in this paper. A few of the most prominently growing E-commerce websites and their recommendation strategy to increase their revenue through sales has also been mentioned here. The future scope of this paper would be studying the vast area of mobile recommender systems.

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