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Movie Recommendation System Based on Collaborative Filtering

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***Abstract*—With the explosively growing of the technologies and services of the Internet, the information data world increases rapidly. Recommendation systems have acted an important role in many ways, including movies, books, friends, shopping on net and music. Especially like today, people are surrounded by mass of information. People try to find their preferred movies. It has become difficult when facing so many kinds of movies. People may dizzied by plenty of items on the net, they don't know how to make a choices. In order to find their preferred movies, they need to spend lots of time on seeking. To help people find their preferred movies quickly, a good personalized recommendation system would be useful for users to choose their preferences. Recommendation technology is one of important applications of Information Filtering, which has been applied broadly in E-commerce. Collaborative filtering is the core technology of personality recommendation, and it is the most widely used and successful technology in recommendation system.**

In this article, we mainly care about the research on characteristic recommendation system. We elaborate and discuss its content, structure, information and recommend technology, and the challenge. In this paper, we did detailed analyses on collaborative filtering technology and also some relative algorithms. Then we made some comparisons with traditional method. At last, we generated a module of recommendation system which contains three important points for people: generate users' preference to do recommendation; use the movies own tags to cluster movies; and calculate the similarity between movies and users. People could obtain the users' description from SNS (twitter). These methods have helped people to choose the movies compared with the traditional way.

Keywords—collaborative filtering; recommendation system; E-commerce;

I. INTRODUCTION & BACKGROUND

Nowadays our daily life has been deeply changed by the internet, people could obtain mass of information by surfing the internet, and this group has been bloom constantly, people in this situation may surrounded by marine information, so the recommender system is born[1][2]. Use the movie recommendation as an example. If we could provide different movies to different people according to users' interest, this way could definitely increase the users' loyalty of the website. Comparing with the traditional shops, usually there will be shopping guides in the shop, they would help customers to find their prefer things. E-commerce is in a rapidly development era, and it has become an important way for merchant to trade. In E-commerce way, customers usually choose their things by searching, and they have a clear goal when shopping on-line, in traditional way, the guides would recommend goods to us which is we haven't reminded but it's really necessary. So in the E-commerce, how to find people's interest and make recommendations to different people according to their different interests has become a problem we need to solve. Merchants could recommend some goods that users may interested in, the effect of recommender systems has been reflected. It can provide personal recommendation services to users. The recent research shows though using personal recommendation service in E-commerce we could improve sales about 2%-8%.[3] We could turn shopping pattern from searching by users, to recommend things to users actively. This brings lots of commercial opportunities to the net. By now different kinds of E-commerce websites have been built, and bring lots of benefits to us.

II. RESEARCH STATUE

Recommendation system is built under the background of the rapid development of internet. Recommender systems or recommendation systems are a subclass of information filtering system that seek to predict the 'rating' of 'preference' that user would give to an item[4], and the personalized recommendation is the main idea of it. Personalized recommendation is used to provide personalized service to users. Recommendation technology is the most key point in recommendation system, and it would affect the performance of recommendation system.

Collaborative filtering (CF) is a technique used by some recommender systems.[4] Collaborative filtering has two senses, a narrow one and a more general one. In general, collaborative filtering is the process of filtering for information or patterns using techniques involving collaboration among multiple agents, viewpoints, data sources, etc. Collaborative filtering methods have been applied to many different kinds of data.[5]

Collaborative filtering is the most widely used recommendation technology. The system would find the most

similar users' group for the client and choose preferred things in this group's items. Collaborative filtering consider if there are some similar comments or rate items in two users, so it may be similar for other items between these two users. Compare with other traditional recommender method like: content based filtering, collaborative filtering could find users' other unknown interests, and because this method concerned about other users comments, so the effect of this method is much higher.

Collaborative filtering is the most widely used method in personalized recommendation application or research, and it is also broadly used in E-commerce, digital library, page search, news filtering [6], a famous recommender system is GroupLens, it is a news filtering system, MoiveLens, movies recommender system, Ringo, it is a music recommender system, and Video Recommendation, it's a CD, DVD recommender system, etc.[7][8]

III. Personalized Recommendation System in E-commerce

A. *Introduction*

Nowadays, with the development of the internet, people is stepping towards the information era, the economy of the internet is blooming. We would meet lots of challenge in our life and daily work, in this kind of situation, E-commerce has increased fast. Recommender systems have become extremely common in recent years, and are applied in a variety of applications. The most popular ones are probably movies, music, news, books, research articles, search queries, social tags, and products in general. However, there are also recommender systems for experts, jokes, restaurants, financial services,[9] life insurance, persons (online dating), and twitter followers[10].In this context, the personalized recommend system comes. Recommendation system is a kind of tool help users solves the information overload problem. Recommendation system leans the traditional ways of shopping, it simulate the function of shopping guides, help client obtain the exact information.

B. *Improvement in recommendation system*

In traditional recommendation systems, they usually use users' preference as the data source. System analyzes users' preference, chooses an appropriate recommendation strategy to generate results. Users' preference usually comes from users' rating score.

In order to improve the accuracy of recommendation system, I propose 2 ideas: combining users' SNS information; clustering movies.

As we know, SNS has become an indispensable part of our daily life. We usually use SNS to share our moods, pictures, something interesting. So we could collect users' SNS information from the Internet, such like their twitters, blogs and moods. Then we could combine this information with movie's description, calculate the similarity between them and choose the movies that users may interested in.

Movies' clustering provides an intuitive way to display the recommendation results for users. Because of each movie has its own tags. Based on this charter, we give the weight for each tag and put tags into different groups by calculating the distance between tags and groups. Then we separate movies into different groups. Users could easily check the groups of movies that they may interested in.

C. *Effect of recommendation system in E-commerce*

Personalized recommendation system for E-commerce is defined as: Personalized recommendation systems for E-commerce provides products' information and refer recommendations, helping users to decide what they need, helping users to finish their purchase. The users of recommender systems is users (users in E-commerce activity), the object of recommendation is items. So the items is the result or service that recommender system provide to users.[11]

Recommender systems used in E-commerce will improve the state of operation in several following ways:

(1)Helping users to find products;

(2) Providing personalized service;

(3)Increasing the sales of products;

(4) Improving the satisfaction of users.

D. *Structure of recommendation system*

The main structure of recommendation system contains: operate database, the library of recommendation module, recommendation engine, interaction and UI.

Database stores the data source which used to do the personalized recommendation, include users' purchase history, register information, browsing information etc.

Library of recommendation module contains the algorithm of the recommendation.

Recommendation engine accepts the users' request and do the recommendation.

Fig.1. shows the structure of recommendation system.

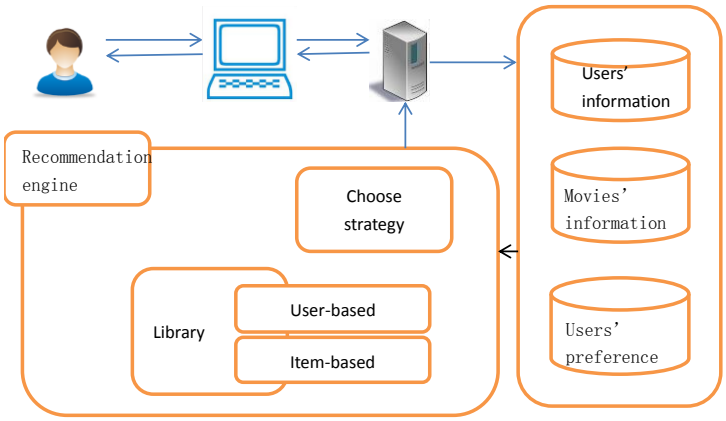

Fig. 1. Structure of recommendation system

E. The business process of common recommendation

Recommendation system has an integrated process for data processing, from data collection to output data. Basically, recommender system contains several processes following:

IV. RECOMMENDATION TECHNOLOGY

Recommendation technology is the most important and critical part in the recommendation system, it affect the performance of the recommendation system. Now, the main recommendation technology includes content based recommendation, rule-based recommendation, collaborative filtering, utility- based recommendation, Knowledge-based recommendation and hybrid recommendation.

A. Content based recommendation

Content based recommendation system is the earliest used technology for information filtering system. Content based recommendation system is derived from information index. System analyses users' factors on purchase behavior, then generate the abstract for users' interest, and do recommendation based on this interest. Content based recommendation is widely used in the internet, Personal WebWatcher, Letizia, syskll & Webert, Libra, Citeser these systems are based on content based recommendation.[12][13][14] Analysis of the items' factors is the key point of this recommendation technology. This recommendation strategy is established on items' content, because of this factor, we need to use much more machine learning methods to analyze items' factor and generate users' interest. In this recommendation methods, system is based on machine learning, learning users' interest and behavior, then find the correlation between users' profile and items. Users' profile module is based on machine learning methods, strategies neural network etc., users' profile in content based recommendation system needs users' history data, record and it may change by users' preference, it could do recommendation for special interest users, recommend unfashionable items.[15]

B. Association Rule-based Recommendation

Association rule-based recommendation is based on association rule, use the items that user has already bought as the head of rule, and the recommend items as the body of rule. This recommendation strategy could find correlation between different items. To manage these rules is to count the proportion that users buy both itemA and itemB. An example for association rule-based recommendation, analyze users' shopping cart to find the relationship between different items, users' shopping behaviors, and find which items has been bought by users at same time. To find these kinds of association rules could help retailer draw up a strategy. In association rule-based recommendation system, finding the association rules is the most cost time process, so usually we off-line way to find rules.

C. Collaborative filtering

Collaborative filtering is one of the earliest and most successfully used recommendation technologies, collaborative filtering recommendation usually use the nearest neighborhoods methods, use users' history preference information to calculate distance between different users, use this nearest neighborhoods set to forecast how much dose target user like this item, then do recommend based on this preference level. Usually, collaborative filtering recommendation is based on users, users could get recommendation by their history purchase or some implicit behavior, and users needn't buy a lot in finding their preference information. Collaborative filtering analyzes the relationship among users, then it uses similar users' preference to do recommendation. Collaborative filtering has some advantages. Collaborative filtering could share other people's experience, it also could help user to find new preferred item. With the development of the internet, the amount of users has increasing, recommendation system should find the nearest neighborhoods set quickly and get the recommendation result.

Collaborative filtering could make up by three parts: create users' profile, find the nearest neighborhoods set, generate recommendation result. Comparing with content-based recommendation, collaborative filtering has several merits:1) it could share other users comment, improve the accuracy, 2) it could find users' new interest,3) it could use other users' feedback.[16]

D. Utility- based recommendation.

Utility-based recommendation is built on users' efficiency of using items; the main point is how to create a utility function for each user. Utility-based recommendation could use properties which are items', like: Vendor Reliability and product Availability to utility computing.[17]

E. Knowledge-based recommendation

Knowledge-based recommendation is not based on users' requirement and preferences; we could regard it as an inference technology. Knowledge-based recommendation is different because of its knowledge function. Function knowledge is a knowledge concern about how to satisfy with particular users, so it could explain the relationship between requirement and recommendation, so users' profile could be any knowledge structure that could support inference.[17]

F. Hybrid recommendation

Because every recommendation technology has its disadvantages, so Hybrid recommendation is widely used. The most widely used and research method is the combination of content-based recommendation and collaborative filtering. The simplest way is respectively using content based recommendation and collaborative filtering recommendation methods to generate a prospective recommendation result, then use some kind of way to combine them. Though there are many kinds of Hybrid recommendation methods, but in a specific problem, it could not be effective, so the principle of hybrid recommendation is avoiding and making up the disadvantages of each recommendation technology though combine these recommendation technologies. In the way of how to combine these methods, researchers come up with seven combination ideas.[18]

G. Comparison among these recommendation technologies

Compare each recommendation technologies, Table I shows the merits and disadvantage of each method.

TABLE I. MERITS NAD DEMERITS OF EACH METHOD

Method	Merit	Demerit
Content-based	Intuition recommend result; Relative domain knowledge is not necessary	New users' problem; Complex properties
Collaborative filtering	New interest developed; Relative domain knowledge is not necessary; The efficiency become better as the time goes by; Personal recommendation	Sparsity; New users' problem; salability
Rule-based	Find users' new interests	Difficult to extract rules; Cost time
Utility-based	No sparsity problem; Concern about items' features	Users need to input functions;
Knowledge-based	Could relate users' requirement and items;	Obtain knowledge is hard

Collaborative filtering method is the most easily and successfully used in recommender system, in factor this method is very sample to understand, this method could find the new interests for users, and the recommendation is depended on other users' comment so the recommender items may have higher reliability then other methods, though collaborative filtering method has so many merits, but when we use user-based collaborative filtering, with the amount of users increased, we need to may meet the accuracy problem, so in next chapters, we would talk about a method to improve the accuracy.

V. MAIN TECHNIC AND ALGORITHM

In this chapter we talk about the main technics used in recommender system.

A. User-based collaborative filtering

User-based collaborative filtering according to users' neighbors' preference information to do the recommendation for target user. And it is based on a hypothesis: If users' some items' score are similar, we could consider the other items' score are similar. Collaborative filtering recommendation use statistical calculation to find the similar neighbors. Then forecast the items' score based on similar neighbors' score, and choose several similar items as the result, and then feeding back to users. This algorithm is not only simple but also has high accuracy; therefore it's widely used by collaborative filtering website. User-based collaborative filtering recommendation's main idea is calculate the similarity among the users. Users-based collaborative filtering is very successful, but now it has come potential problems, sparsity, extensible.[21]

In user-based collaborative filtering recommendation, there contains a user set: U{u_1,u_2,u_3…u_n}, and each users contains an item set: I{i_1,i_2,i_3…i_n}, and every users has make a comment for each item. Example: Table II shows users' score matrix.

TABLE II. USER'S SCORE TABLE

Items / User	Iron Man	Bat-Man	Avatar	Superman
John	4	4	5	4
Mary	3	4	4	2
Peter	2	3		3
Tom	3	5	4	Forecast score

From this table we could easily find that Mary is the most similar user for Tom. So Mary's score for Superman is the highest weight for Tom to forecast score. Comparing with John and Peter, we could find that they are not the most similar user for Tom, so the effect on score forecast should be less.

So the most important part for User-based collaborative filtering is: calculate the similarity among the users, find the most nearest neighbors, and forecast.

B. Cosine

We could regard every users' comment for items as a vector in N-dimensional space, and set the blanket comment items as 0, this measure calculates the similarity according to calculate cosine between the user vectors. Assume: $\vec{\imath}$ $\vec{\jmath}$ represent user I and user J's score in N-dimensional space, The cosine-based approach defines the cosine-similarity between two users i and j as:[22]

$$\text{sim(i, j)} = \cos(\vec{\imath}, \vec{\jmath}) = \frac{\vec{\imath} \cdot \vec{\jmath}}{||\vec{\imath}|| * ||\vec{\jmath}||} \quad (1)$$

C. Adjusted Cosine

Because of the regardless of scale for different users' score in cosine, some users may have a high comment, some users may give a low score, adjusted cosine subtract users' average score to improve this defect. Sim(x,y) represents similarity between $user_x$ and $user_y$, I_{xy} represents the common items in u_x and u_y, I_x and I_y separately represents u_x items' score and u_y items' score, r_{xi} and r_{yi} separately represents u_x score for item i, and u_y score for item i, $\overline{r_x}$ represents u_x's average score, $\overline{r_y}$ represents u_y's average score.

$$\text{sim(x, y)} = \frac{\sum_{i \in I_{xy}} (r_{xi} - \overline{r_x})(r_{yi} - \overline{r_y})}{\sqrt{\sum_{i \in I_x} (r_{xi} - \overline{r_x})^2} \sqrt{\sum_{i \in I_y} (r_{yi} - \overline{r_y})^2}} \quad (2)$$

D. Pearson correlation

To calculate the correlation, we use Pearson measure to scale, sim(x,y) represents the similarity between $user_x$ and $user_y$, I_{xy} represents the common items set in $user_x$ and $user_y$, r_{xi} and r_{yi} separately represents u_x score for item i, and u_y score for item i, $\overline{r_x}$, $\overline{r_y}$ represents the average item score for u_x , and u_y.

$$\text{sim(x, y)} = \frac{\sum_{i \in I_{xy}} (r_{xi} - \overline{r_x})(r_{yi} - \overline{r_y})}{\sqrt{\sum_{i \in I_x} (r_{xi} - \overline{r_x})^2} \sqrt{\sum_{i \in I_y} (r_{yi} - \overline{r_y})^2}} \quad (3)$$

E. Create users' profile

- Collect users' personal information: name, gender, age, career, personal description.

- Collect users' SNS information.
- Collect users' rating information for movies.

Once we create users' profile, we could create users' preference. Here we use users' rating as preference. Use users' preference to calculate the similarity between target user and other users (using Pearson correlation). Choose the nearest K neighborhoods set. Use this set to forecast score.

F. Generate the recommendation result

We need to find the target user's neighbors set recorded as N_i , according to K-neighbors. We forecast the scores that target user didn't make the comment, then we recommend the highest top-N items to target user. $P_{i,y}$ represents $user_i$'s forecast score for $item_y$, $\overline{r_i}$ represents $user_i$'s average score, $\overline{r_j}$ represents $user_j$'s average score, sim(i,j) represents the similarity between $user_i$ and $user_j$.

$$p_{i,y} = \overline{r_i} + \frac{\sum_{j \in N_i} sim(i,j) * (r_{j,d} - \overline{r_j})}{\sum_{j \in N_i} (|sim(i,j)|)} \qquad (4)$$

We collect user's SNS information as users' description. Here we could collect user's twitter from the internet. Then we could get users' description like:

Transformers is really amazing, I love to watch such kind of action movie, full of science story, and huge scene, stunt, special effects. People in the movie fight for their faith….

Then we could extract key words from this information use Lucene, filtering some insignificant words like: "is", "of", "to"…, sometimes, User want get "he", when the select "He", so we need to put all words uppercase; Users want to get "lives" when they searching "lived", so we need to restore the words to original type; and sometimes, the punctuation marks are not very important, so we need to filter them. Count the frequency of each key words, thus we could get a vector for this result :{a_1, a_2, a_3,…,a_n} a_i represents the frequency of word number i. Use the same to get a vector for movies' description: {a_1, a_2, a_3,…,a_n}, use Pearson correlation method to calculate similarity between them, choose the most similar items.

G. Movie clustering

Once we get the recommendation results, user may usually concern about which one is good among these movies, in order to help people find their prefer movies quickly, clustering is a better way for us to help users to classify movies.

Because each movie has its own tags, so could use these tags to calculate the distance between each movies, $co(T_i, T_j)$ represents the correlation between tag_i and tag_j, $Num(T_i \cap T_j)$ represents the amount of movies that have the both contains T_i and T_j , $Num(T_i \cup T_j)$ represents the amount of movies that contains T_i and T_j .

$$co(T_i, T_j) = \frac{Num(T_i \cap T_j)}{Num(T_i \cup T_j)} \qquad (5)$$

Because these movies contains 17 types of tags : Action, Adventure, Children's, Comedy, Crime, Documentary, Drama, Fantasy, Film-Noir, Horror, Musical, Mystery, Romance, Sci-Fi, Thriller, War and Western, so we could provide 17 options for users, each tag represents an option, users could choose each of these tags, then we cluster movies into groups that they have chosen.

Sometimes movies contains more than 1 tags, and these tags may be put into different groups, so the movie should have a main tag, and this tag has the highest weight, we put this tag at the first position of movie's tag, if movie's tags are clustered into different groups:1) if the tags' amount in each groups are different, we put the movie into the group which contains greater number of tags; 2) if the tags' amount in each groups is same, we put movies into its main tag's group.

VI. MEASUREMENT METHOD

In this situation, we use 5 users, who have watched 25 movies, r'_i represents the true score that user gives to item i, r_i represents the users' forecast score for item i, then we could calculate mean absolute error (MAE), use MAE as the measure index, N represents the account of items.

$$\text{MAE} = \frac{\sum |r'_i - r_i|}{N} \qquad (6)$$

Here we need to modify the forecast score method, $sim(U_d, I_d)$ represents the similarity between user's description and movies' description.

$$p_{i,y} = \overline{r_i} + \frac{\sum_{j \in N_i} sim(i,j) * (r_{j,d} - \overline{r_j})}{\sum_{j \in N_i} (|sim(i,j)|)} \pm sim(U_d, I_d) \qquad (7)$$

Here we need to modify the forecast score method, $sim(U_d, I_d)$ represents the similarity between user's description and movies' description.

Fig.2. shows the users' score accuracy comparison between traditional user-based collaborative filtering and modified combination-method. If the value of MAE is smaller the accuracy of this method is higher. From this graph, we could easily tell that the combination method has a lower MAE value, so the accuracy of this method could be much better than traditional user-based collaborative filtering.

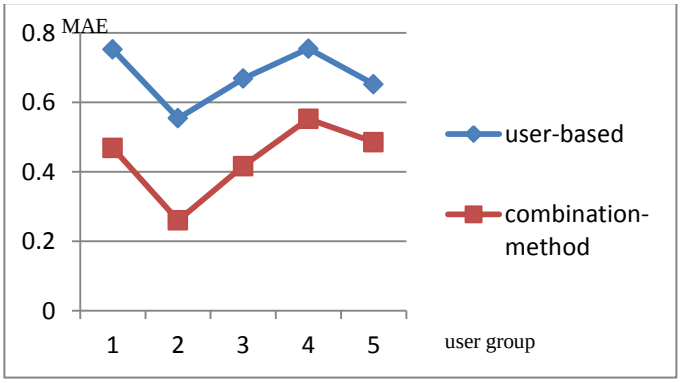

Fig. 2. Comparison between a traditional user-based method and a combination-method

And we have received the information from users' daily life. Because we extract their description or their SNS information

from twitter, we could tell that the strategy of this system how to recommend movies is much close to our daily life rather than traditional user-based collaborative filtering way.

VII. SUMMARY

With the development of internet, recommendation system has become part for each web site, and the recommendation technologies have been widely used in many fields, including music, book, movies, news, friends, and electronic goods etc. These technologies have abstract many sights. Collaborative filtering is the most widely used and successful technology. This paper has done lots of research on this technology, based on the basic knowledge about collaborative filtering. We also cluster the movies, consider about the weight in each movies. This provides a new way for users to get the precise recommendation results. In order to improve the accuracy of recommendation result, we use the SNS information on the internet. Users could obtain their twitters from the internet and extract the key words from their twitters and descriptions. At last we calculate the similarity with movies' description, modify the conditional score formula and generate a new recommendation result. Based on these technologies, we create a movie recommendation system.

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