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A Concise Analysis of Various Recommendation Methods and Techniques for Efficient Recommender Systems

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***Abstract*—Recommender Systems are eminently in demand to manage the problem of highly overloading data and to avoid the retrieval of irrelevant information from Web, which is a major part of Information Filtering. Recommender Systems helps user to make precise and explicit decisions and study the user's knowledge to enhance the Business growth. Different Recommendation methods are implemented for achieving varied recommendations in numerous vital applications based on the expected behavior of the system and relevant data mining strategies are used to perform efficient information retrieval. This paper analyses the various Recommendation methods available for building effective Recommender Systems and exploits the participation and usage of Recommendation methods in different domains. This paper also focuses to discuss Data Mining techniques and their scope towards implementing such effective Recommender Systems.**

***Keywords*—Recommendation Algorithm; Content Based Filtering; Collaborative Filtering; Hybrid Recommendation; Knowledge Based Recommendation; Group Recommendation; Data Mining Methods;**

I. INTRODUCTION

The tremendously growing Web extends its support to society through various perspectives and, one among them is the powerfully developing Recommender systems. As information is getting overloaded day by day, decision making is becoming a complex activity for the users. To overcome this complexity, Recommender Systems are developed to suggest users with choices to take precise decision. The application of Recommender systems are found in a wide range of domains such as e-government, e-library, e-learning, e-tourism, e-resources etc...

Recommendation methods act as an information agent that analyses and predicts the recommendations exploring user's preferences from a largely loaded data. Nowadays most of the Web applications use recommendation techniques to provide user preferred recommendations that increases the usage of the application and also encourages users to make decisions effectively. This recommender system considers various features to generate recommendations and implements different types of recommendations corresponding to the features. So web applications supported in different devices, belonging to various fields began implementing this successful methodology and gets benefited. This paper discusses such Recommendation methods, features considered for recommendations, advantages and disadvantages and illustrates Recommender Systems contribution and usage in numerous fields. This paper also describes the Data Mining techniques which can be proficiently used in Information Retrieval, Extraction and Recommendations.

II. RELATED WORK

R.Akil Sindhu and Dr.R.Manicka Chezian [1] made a comparative study on the positive movement of Web from Web 0.0 to Web 5.0. Jie Lu, Dianshuang Wu et al. [2] presented a survey on various Recommendation methods and the successful Recommender systems in enormous fields which illustrated the impact of growth of Recommender systems in our society. R.Akil Sindhu and Dr.R.Manicka Chezian [3] illustrated the development of Semantic Web and Ontology, its layered Architecture, Operations with a practical scenario.

RVVSV Prasad and V Valli Kumari [4] presented the state-of-the-art of Recommendation methods and the related functionalities. Daniar Asanov [5] discussed the different algorithms and methods used to develop the Recommender Systems along with their practical challenges occurring. Zuping Liu [6] provided collaborative filtering based on user interests (CFBUI) algorithm to perform mining based on user's interest applying the correlation and similarity measures. Sihem Amer-Yahia et al. [7] attempted to define the semantics and explore the efficiency of presenting recommendations to groups of users. Francesco Ricci et al. [8] gave an overview of the important data mining techniques

which can build efficient Recommender Systems. Poonam B.Throat et al. [9] produced a survey on Collaborative Filtering, Content-Based Filtering and Hybrid Recommended Systems, their Challenges, techniques and presented the applications implemented with such system. Neethu Raj and Suja Rani M S [10] discussed various recommendation methods and its description and narrated the importance of Recommender System.

Lalita Sharma et al. [11] presented detail representation of Content Based and Collaborative Filtering methods and its implementation techniques. Ruchita V. Tatiya et al. [12] presented the paper focusing on the solutions to overcome the drawbacks during recommendations and deals with the solution to provide apt recommendations of the services to the users in big data environment using Hadoop. Majid Hatami and Saeid Pashazadeh [13] implemented a modified Resnick prediction formula to improve the predictions in Collaborative Filtering based Recommender System and proved the results compared with Resnick prediction formula.

III. RECOMMENDATION METHODS

Recommendation methods can be categorized in to several types based on their approach and features concentrated while producing recommendations, based on which several Recommender systems are built. The Recommender systems are classified as:

- Personalized Recommender Systems
- Non-Personalized Recommender Systems

Fig.1 illustrates the perspective of a Recommender System.

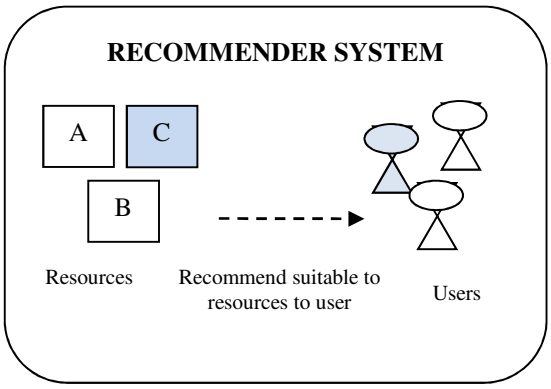

Figure 1. Recommender System's Perspective

Personalized Recommender Systems: Personalized Recommender systems generate recommendations based on user preferences, rating history of visits and comments. These depend on user profiles and collaborative contents determine the recommendations. So the recommendations suggested will vary from users to users.

Non-Personalized Recommender Systems: Non-Personalized Recommender systems suggest Recommendations based on popularity and users opinion of the resources. As the recommendations are non-personal, it provides similar recommendations to users. The major categories of Recommendation methods are:

A. CONTENT BASED FILTERING

Content-Based filtering (CB) provides Recommendations analyzing the description of resources, tags and keywords associated with description of resources and user preferences such as , users past history with respect to the users profile. The resources that are positively rated by the users are considered and their similarities are examined based on individual user with respect to their profile and the positively rated resources are recommended.

B. COLLABORATIVE FILTERING

Collaborative Filtering (CF) is the method of filtering data for recommendations based on the set of user preferences and correlations that are common. It analyses the similar interest shared by the group of people and builds a neighborhood. Collaborative filtering offers User-based CF AND Item based CF.

User based CF provides recommendations based on items liked by other users sharing similar tastes and Item-based CF provides recommendations based on the similarity of items the individual preferred in their past usage. Pearson correlation-based similarity, constrained Pearson correlation (CPC)-based similarity, cosine-based similarity can be used to calculate the similarity measurement among users.

C. HYBRID RECOMMENDATION

To overcome the shortcomings of traditional recommendation techniques, best features of two or more recommendation techniques are combined in to hybrid recommendation technique. It widely combines content-based recommendation method and collaborative filtering method to form a hybrid method. The major hybridization mechanisms of combinations used in recommender systems to build hybrids are weighted, mixed, switching, feature combination, feature augmentation, cascade and meta-level.

D. DEMOGRAPHIC RECOMMENDATION

The demographic profile of the user is used to generate recommendations. The attributes, such as age, gender, language and occupation, are considered for

recommendation purpose along with user ratings. Recommendations generated are based on the demographic features. Fig.2 presents the various features considered for generating recommendations in a system.

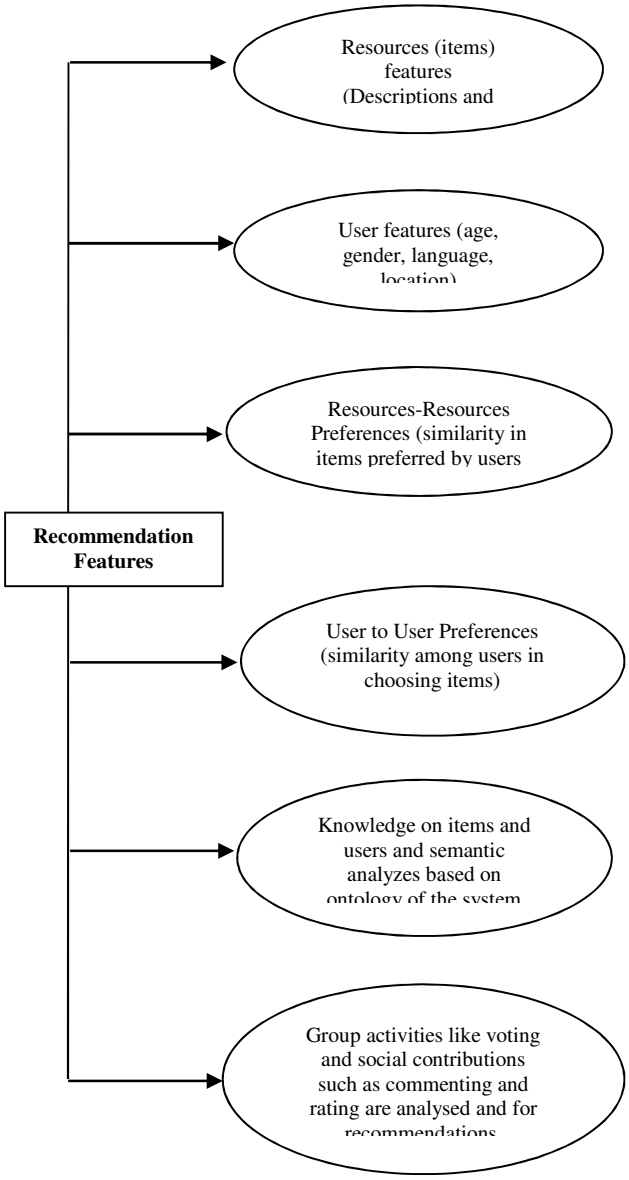

Figure 2. Features to generate Recommendations

E. KNOWLEDGE-BASED RECOMMENDATION

Knowledge-Based (KB) recommendations are generated predicting relation between the knowledge about the users and Items. Ontology is used to represent the knowledge and Semantics by examining the domain concepts while building this recommender system. So, the semantic based recommender systems are built based on knowledge base created defining ontology. Apart from the traditional recommendation methods, some advanced recommendation methods based on the domain requirements, are generated they are:

F. GROUP RECOMMENDATION

Group recommendation (GR) method produces recommendations based on group of user suggestions. It enables user aggregation in to groups and analyses the group activity such as voting, sum etc...

G. CONTEXT AWARENESS-BASED RECOMMENDATION

Context awareness-based recommendation (CA) method incorporates the contextual Information for recommending items to users in specific circumstances. It characterizes the user's situation of an entity which can be a person, a place, or an object, with respect to time, geometric information.

H. SOCIAL NETWORK-BASED RECOMMENDATION

To enhance user experience, Social Network-Based (SN) Recommendations techniques progressively enables users to involve in social interaction with other users, such as making online friends, making social comments and tags, etc. "Trust" is a deeply discussed relationship and it is proved to have high correlation with user similarity in online communities.

I. COMPUTATIONAL INTELLIGENCE-BASED RECOMMENDATION

Computational Intelligence is the study to implement Intelligent Agents, where agents can be any real world entity. It builds intelligent systems and provides recommendations based on its intelligent information filtering through techniques and learning ability from the experiences. Some of the Computational intelligence (CI) techniques include Bayesian techniques, clustering techniques, artificial neural networks, genetic algorithms and fuzzy set techniques to construct recommendation models.

As the information technology is bringing lot of advancements to the society, searching and utilizing the knowledge available in Web is made easy, promoting precise decision making based on the acquired knowledge, and interests in different domains using this recommendation techniques.

These Recommender Systems play a vital role in recommending good resources to users. Table.1. presents

the notable advantages and disadvantages of the Recommender Systems. The challenges faced while building Recommenders systems and the positive significance of the system are discussed in the Table.1.

TABLE 1. ADVANTAGES AND DISADVANTAGES

ADVANTAGES	DISADVANTAGES
It helps user to take satisfied and fastest decisions explicitly.	There can be chances when recommendations can be inappropriate.
It helps the growth of business in every domain.	It may cause recommendations for Promoting business.
It helps the system to identify the knowledge of user.	It can face complexity in updating the changes and recommending new resources at times.
It analyses and collects data based on the user behavior, preferences, rating, and history considering user profile; individually and collaboratively with respect to trust factor.	**Sparsely:** The data sparsely problem due to insufficient rating and collaboration. **Cold start:** when a new user or item or a new system is introduced, this problem is faced. **Scalability:** when there is information overloaded, then system faces this problem.
It brings socialism and creates user aggregation to build Intelligent recommender systems with available recommendation methods.	Due to the wide growth of users and resources, Similar problems such as , Big Data problem, Specifying exact features for recommendations, First ratter problem, Long tail problem, Quality dependent etc... are the commonly occurring problems faced on collecting data to recommend.

Fig.3 presents the overall percentage of suitable recommendation methods used to develop the recommender systems.

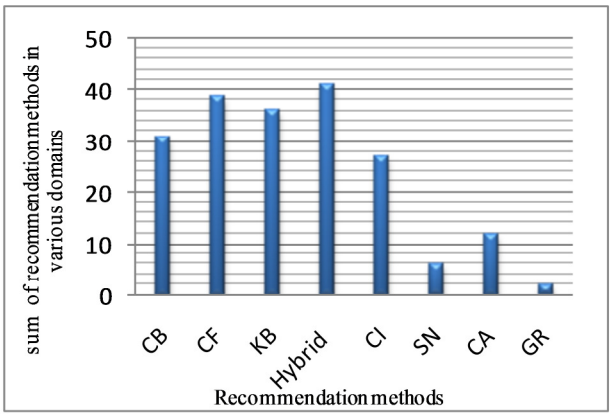

Figure 3. Usage of different Recommendation methods

Fig.4 represents the overall percentage of recommender systems developed in numerous fields such as e-government, e-library, e-learning, e-business etc....

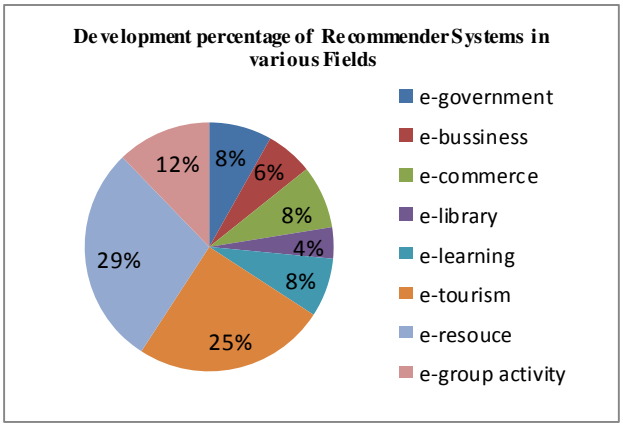

Figure 4. Development percentage of Recommender Systems in Various Fields

IV. DATA MINING METHODS USED FOR RECOMMENDER SYSTEMS

A. *SIMILARITY MEASURES*

The Similarities and Distance Measures are calculated and used to explore "group recommendations" and "collaborative analysis" in collaborative Recommender Systems. The formula commonly used to calculate the similarity measures are:

1) Minkowski Distance

$$d(\mathbf{x}, \mathbf{y}) = \left(\sum_{i=0}^{n-1} |x_i - y_i|^p \right)^{1/p}$$

When p=1, Manhattan distance can be measured, When p=2, Euclidean distance can be measured.

2) Correlation Coefficient

When there is high mean variance found among data, the Pearson correlation coefficient is the efficient technique used to analyse it.

$$p_{xy} = \frac{Cov(r_x, r_y)}{\sigma_x, \sigma_y}$$

B. DIMENSIONALITY REDUCTION

The dimensionality reduction is used to remove the irrelevant attributes and reduce the dataset size by removing such irrelevant attributes which are nothing but the dimensions that "efficiently choose the attributes to produce recommendations in such Recommender Systems".

C. CLASSIFICATION

Classification is the process of exploring the data samples that are newly evolving and labelling them. Application of Decision Tree Algorithms such as ID3 Algorithm, C4.5 Classifier, Naive Bayesian Classifier are applied to implement the classification technique in Recommender Systems, which supports to "efficiently handle the data overloading and data retrieving, when new data are added to the system dynamically". Entropy and Information Gain are the major factors considered to precede the technique. The common formula used to achieve this Data Mining Technique is,

1) Decision Tree Algorithm

$$Entropy(x) = \sum_{i=1}^{k} -p_i \, log_2 \, p_i$$

Here X is the training dataset and (x_1, x_2… x_n) are the classified samples with *P,* be the dimensional vector from (p_1, p_2… p_n) representing the attributes of classified Samples and Information Gain is the measure of change in the entropy.

2) Naive Bayesian Classifier

$$P(C \mid A) = \frac{P(A \mid C)P(C)}{P(A)}$$

Where P(C|A) is the posterior probability of C conditioned on A. P(C) is the prior probability. P(A), P(C) and P(A|C) are estimated from the analysed samples. Classification is performed based on these probabilities.

D. CLUSTERING

"The data distribution and analysis of similarities among data to group them as clusters is implemented with the clustering technique, which helps to handle the large amount of data available to produce recommendations in such Recommender Systems".

The approaches to perform clustering are "hierarchical clustering and partitioning clustering" and Numerical and categorical. The reputed algorithms under clustering techniques are "k-MEDIOD Algorithm, k-MEANS, CLARA and CLARANS (Clustering Large Applications based on Randomized Search) etc…

E. SUPPORT VECTOR MACHINE

The binary classification and regression estimation tasks are performed using Support Vector Machines. A hyper plane is determined forming a linear separation between classes. If the separated classes are considered as A and B, then their similarity distance measure can be calculated to analyse the optimization problem. The Support Vector Machine is a Supervised Learning technique that supports optimized classification of data.

F. ASSOCIATION RULE MINING

Association Rule Mining is another efficient approach to find out the "frequently mined data". And the SUPPORT and CONFIDENCE remains the major factors which determine the frequent items and the accompanying items purchased. This technique explores "the interesting relations among data and the measures of interestingness" which enhances the business. Apriori Algorithm, FP-Growth Algorithm (Frequent Pattern Growth), Elcat (Equivalence Class Transformation) is the commonly implemented algorithms to achieve this mining technique.

G. OTHER IMPORTANT DATA MINING TECHNIQUES

There are numerous efficient data mining techniques available to manage data pre-processing, data cleaning, data staging, data compression, data integration and transformation, data reduction, Discretization and evolving concept hierarchies etc…Similarly Artificial Intelligence, Genetic Algorithm, Neural Networks, Principle component Analysis etc….can also be implemented to process the data successfully and generate Recommendations.

V. CONCLUSION

This paper analyzed the different Recommendation methods available to build Recommender Systems based and the Features considered for Recommendations and presented the contribution of Recommendation methods in different fields along with its advantages and disadvantages. This paper also covers the representation of available data mining techniques to implement such Recommender Systems. As the Web grows immensely, the facilities to recommend resources also grows together, supporting creation of recommendations not only from a single user perspective, but also from multiple users suggestions through commenting, rating, voting etc... and those especial features are considered to implement Recommendations.

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Authors Profile

R.Akil Sindhu received her M.Sc., in Software Engineering from MCET, Pollachi under Anna University, Chennai in 2012. She worked as a Software Engineer from 2013 to 2015 in HCL Technologies Ltd, Chennai. Currently she is a Research Scholar in Department of Computer Science, NGM College, Pollachi under Bharathiar University, Coimbatore. She has presented her Research Papers in National and International Conferences and received Best Paper Award. Her Areas of interest includes Data Mining, Semantic Web Mining, and Ontology Engineering.

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