

# Personalized Movie Recommendation System Using CF and Time Varying Multi-Armed Bandit Algorithm

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**ABSTRACT:** A recommendation system is a type of information filtering system which attempts to predict the preferences of a user, and make suggests based on these preferences. Similarly movie recommendation system helps the user to select out a movie from a set of similar movies. The goal of recommendation system is to maximize the user satisfaction using their consumption history and gathering new information for improving the goodness of match between the user preferences and items. But that system strives to promptly suggest users appropriate items according to their current context including user and item information. The lack of interaction records for new users also in flames the performance of recommendation system (cold start problem). To deal with this challenge, the idea of collaborative filtering (CF) using multi armed bandit setting mechanism is adopted to recommendation system. In CF, there is an assumption that the items(movies) are independent. But it rarely holds in real world applications. The items are correlated with each other. So, item dependencies are formulated as clusters of arms in bandit setting where arms (items) within a single cluster share similar behavior. The dynamic behavior of items or users in bandit setting may vary with time. This will definitely affect the reward patterns in bandit setting. So to capture the time varying behaviour of patterns, we propose time varying multiarmed bandit model. For evaluating the proposed algorithm, we use a real world data set called MovieLens. It includes 71,657 users, 10,681 movies and 10,000,054 ratings. The proposed work introduces an interactive CF model that utilizes time varying bandit algorithms with dependent arms for recommending appropriate items for target users.

**KEYWORDS:** Recommendation techniques, optimization algorithms, multi-armed bandit algorithm

## I. INTRODUCTION

Recommendation system is a type of information filtering system and makes suggestions to users based on past usage and preferences of users. Today importance of recommendation system is very high due to dependence of humans on social media and internet. Recommendation system has its applications on various domains. The main motivation behind using recommendation system is that, it is based on real activity. Any recommendation system consists of two basic entities. First one is user and second one is item. Based on the ranking on items by the users, the recommendations are made. The output of recommendation system is depending upon the type of input given to the system where input may be either rating or data in recommendation system. The rating is generally suggestions made by the users on an item. Data can be age, gender, education of users and so on. Based on these inputs, the output of recommendation system will be predictions or recommendations. The technique used for recommendation is known as recommendation techniques. A. Recommendation Techniques A variety of approaches have been used to provide recommendation like collaborative filtering, content based and hybrid approach. Different Algorithms and approaches are there to provide recommendation that may use rating or content information; however collaborative filtering and content based method suffer from same limitations. Several researchers have tried to overcome these limitations by integrating these techniques with some kind of optimization algorithms. Such a method is hybrid approach that combined ratings as well as content information. Recommendation system will always remain active search area for researchers. The recommendation techniques are majorly classified into three. They are

- Content based filtering
- Collaborative filtering
- Hybrid filtering technique

In content-based approach, similar items to the ones the user preferred in past will be recommended to the user while in collaborative filtering, items that similar group people with similar tastes and preferences like will be recommended. In order to overcome the limitations of both approach hybrid systems are proposed that combines both approaches in some manner. This type of filtering techniques filtering built on the customer preferences and description about the item. Basically, these algorithms aim to suggest items or product which are alike to that items that user enjoyed in past or is looking at in the present-day. Data sparsity as well as cold start problem are eliminated in content based filtering. Data about users are not required for recommending items in content based based filtering. These are considered as the advantages of content based filtering. Disadvantages of this type of filtering is that to define the item features, content analysis is essential.

Collaborative filtering: Collaborating filtering approaches build the system by considering the user's past behavior viz rating given to those items previously purchased or chosen. The rating given by similar users will also be considered in this regard. then the system computes the items to be recommended from this. Collaborative filtering suffers from the Cold-Start problems. This will be eliminated by using user demographics. Collaborative filtering are broadly classified as

- Item based CF
- User based CF

The excellence of recommended items are estimated through user ratings. This is considered as an advantage of collaborative filtering

Hybrid filtering: Hybrid method of recommendation is a recommendation technique which uses any of the recommendation techniques and an optimization algorithm or are built by joining different recommender system techniques to build a more robust framework. Hybrid recommendation system gives higher recommendation accuracy compared to content based and collaborative filtering methods in movie recommendation, the domain pertinent to the research.

#### B. Multi Armed Bandit Problem

The multi-armed bandit problem[4] is a classic example to demonstrate the exploration versus exploitation dilemma. This post introduces the bandit problem and how to solve it using different exploration strategies. It is a classic reinforcement learning example where we are given a slot machine with  $n$  arms (bandits) with each arm having its own rigged probability distribution of success. Pulling any one of the arms gives you a stochastic reward of either  $R=+1$  for success, or  $R=0$  for failure. Our objective is to pull the arms one-by-one in sequence such that we maximize our total reward collected in the long run. The multi-armed bandit problem is a classic problem that well demonstrates the exploration vs exploitation dilemma. Imagine you are in a casino facing multiple slot machines and each is configured with an unknown probability of how likely you can get a reward at one play. The question is: What is the best strategy to achieve highest long-term rewards?. This will only discuss the setting of having an infinite number of trials. The restriction on a finite number of trials introduces a new type of exploration problem. For instance, if the number of trials is smaller than the number of slot machines, we cannot even try every machine to estimate the reward probability (!) and hence we have to behave smartly w.r.t. a limited set of knowledge and resources (i.e. time). A naive approach can be that you continue to playing with one machine for many many rounds so as to eventually estimate the true reward probability according to the law of large numbers.

## II. RELATED WORK

Recommendation system is a model which predicts the user preferences and forms suggestions based on these predicted preferences. This section deals with the background study of recommendation system and recommendation techniques. C Agarwal "Recommendation System" is a text book which gives the basic background study of recommendation system. This book includes the ideas about how recommendation system works and types of recommendation techniques [1]. Dolly Sigroha et, al. discussed the basic recommendation techniques for recommendation [2]. A comparative study on various recommendation techniques are done. Study reveals that, among two techniques, content based filtering has more accurate recommendation than traditional collaborative filtering technique. Bhumika Bhatt et, al. reviewed a paper on machine learning based approaches and techniques in recommendation. This paper represents the overview of Approaches and techniques generated in recommendation system. Recommendation system is categorized in three classes: Collaborative Filtering, Content based and hybrid based Approach. This paper classifies collaborative filtering in two types: Memory based and

Model based Recommendation .The paper elaborates these approaches and their techniques with their limitations. This survey shows the road map for research in this area. The authour substantiates the use of hybrid algorithm in recommendation context as the best.[4]. Yagnesh G. patel et, al. discussed a study on various techniques of recommendation system in web mining. This study shows the recommendation system related research and introduce various techniques and approaches used by the recommender system. User-based approach, Item-based approach, Hybrid recommendation approaches.The study justifies that the hybrid method of recommendation is the best in web mining context.[5]. Priyanka et,al. introduces Various Algorithms on Recommender System[6].Dr. Shelbi Joseph et, al. introduced a comparative study on recommendation system types and its classifications.[7] Rui Chen et, al. discussed about the Collaborative Filtering-Based Recommender Systems.[8]. The overview of recommendation system and various techniques are understood from the above study. Among the various recommendation techniques, the hybrid filtering technique of recommendation has better recommendation performance compared to content based collaborative filtering and collaborative filtering technique. These survey papers give an insight of background study of recommendation system and recommendation techniques. Recommendation system are popular and used in many fields for gathering the information based on the user requirements. It is mainly used to help the user for accessing the process based on the relevant information. Many framework for recommendation systems based on the different algorithms are revolve around the concept of accuracy only but other important feature such as diversity of the recommendations are unnoticed. To make the recommendations accurate, efficient optimization technique along with the recommendation technique is used for providing more diverse recommendations by satisfying the requirements recommendation features. This section deals with the study of different optimizations techniques used in the field of movie recommendation. D.K. Yadav et, al. proposed a paper named A Movie Recommender System: MOVREC.The user can then browse the recommendations easily and find a movie of their choice. The recommendation technique used here is collaborative filtering and optimization algorithm used is k means. So this collaborative filtering along with k means is a hybrid technique of recommendation. The only disadvantage of this system is to determine the value of K. [9] Rahul Katarya et, al. proposed a recommendation system which uses collaborative filtering technique along with cuckoo search optimization technique.[10]. Rahul Katarya et, al. proposed a hybrid movie recommendation system using collaborative filtering technique and particle swarm optimization technique (PSO). The limitation of this work is PSO convergence take time, random initialization of particles position and velocity vector.[11]. Qing Wang et, al. discussed a hybrid movie recommendation system using collaborative filtering and multi armed bandit algorithm with arm dependencies[12]. Various optimization algorithms viz cuckoo search optimization, particle swarm optimization,multi armd bandit algorithm etc were discussed in this section. These optimization algorithms are performed along with collaborative filtering technique for accurate recommendation. A comparative study on some of general optimization algorithm is done. The study justifies that , multi armed bandit optimization algorithm along with CF filtering are more efficient and gives better recommendation accuracy. Personal movie recommendation system is a type of information filtering system which helps to recommend movies to individuals. This research domain consists of some of relevant works which are related to personal movie recommendations.Study on this domain brings out that the result that collaborative filtering along with an optimization gives better recommendation results. Shreya Agrawal et, al. introduced a personalized movie recommendation system which combines two techniques of recommendation such as content based filtering and collaborative filtering. The advantage of this recommendation system is that it solves cold start problem and has improved recommendation accuracy. But the computational overhead and time of computation will be high. Because it combines tworecommendation techniques. This recommendation system also does not considered about the time varying preference of users and items[13]. Qing Wang et, al. proposed a personal movie recommendation system that uses collaborative filtering techniques and multi armed bandit algorithm. The output recommendations obtained as a result of collaborative filtering is formulated as multi armed bandit problem. The multi armed bandit algorithm is used as an optimization algorithm. So this system uses a hybrid approach of recommendation. The feedback is given to system for making the future recommendations better. The limitation of this system is that it does not consider about the time varying user preference and item preference[12]. Ching-Seh (Mike) Wu et, al. discussed a personal movie recommendation system using collaborative filtering technique. It compares the performance of item based collaborative filtering and user based collaborative filtering. By using the technique of collaborative filtering, cold start problem is avoided. The limitation of this paper is that, it is not a hybrid recommendation technique[14]. A. Findings Content based filtering and collaborative filtering are the commonly used two techniques for recommendation. Both the techniques have certain disadvantages, that inhibits the performance of recommendation. To improve the recommendation accuracy, hybrid technique of recommendation was proposed. Personalized movie recommendation are not aware about the time varying preferences of users and movies, which inhibits the performance of system.Time varying property of user and item are considered by using time varying multi armed bandit optimization algorithm. So collaborative filtering along with time varying multi

armed bandit algorithm gives better recommendation performance compared to other hybrid recommendation system.

### III. METHODOLOGY

#### A). Data description

The dataset used for designing the movie recommendation system is MovieLens dataset. It includes three types of files. They are movies.dat, ratings.dat and tags.dat. This data set contains 10000054 ratings and 95580 tags applied to 10681 movies by 71567 users of the online movie recommender service MovieLens. Users were selected at random for inclusion. All users selected had rated at least 20 movies. Each user is represented by an id, and no other information is provided.

#### B). Dataset preprocessing

Preprocessing of movies.data file structure and rating.data file structure are done in this step. Missing values in both data files are eliminated. Feature sets and title set are extracted and stored using array and array list data structures. verification of uniques ids to each users are done. Time stamp information in MovieLens are represented in seconds in UTC format and stored efficiently as a key value pair using hash map data structure. This time stamp information is converted to user understandable format. These are the preprocessing steps done in the preprocessing module. Two matrices are created in this step. The data files used are movies.data and ratings.data. User movie rating matrix and movie type matrix will input to collaborative filtering technique. Then movie recommendations are obtained. The Recommendations are optimized by using multi armed bandit algorithm. These obtained recommendation to a user are formulated as arms of multi armed bandit. Then a score is calculated to each item by using the time stamp information. The item with highest score is pulled and a reward is obtained. This reward is given in the form of rating. This rating is feed back to system for making future predictions accurate. Through this, a prediction model is created. When a new user is arrived, recommendations are made by using this prediction model.

#### C). Rating optimization

Multi armed bandit algorithm is used for optimizing the recommendations. Preference of movies or preference of users may vary with the time. These are not considered in the existing recommendation system. A user does not get appropriate recommendations when the system is not aware of the time varying preference of user or movies. So to get perfect recommendations, an optimizing algorithm is essential. Multi armed bandit algorithm is the optimization algorithm used in this work. In this step, the rating matrix is the input to the system. The time varying preferences of movies are considered by a small decrement(delta value). Recent movie have high preference. The preferences are decremented by a small delta value for the old movies. When a user login to the system, a score is calculated for the movies based on this delta value and rating value. Among these score calculated movies, the system pick up the movie with highest score for the user. Then the user rates the movie by a value within limit of 5. The rating of this movie is updated in rating matrix by calculating average of old score and user given rating. Then the score is set as a threshold value for the future recommendations. Thus the rating matrix is optimized and updated.

#### D). Movie recommendation

Recommendation of movies are made by using the technique of collaborative filtering. Collaborative filtering system recommends items based on similarity measures between users and/or items. The system recommends those items that are preferred by similar kind of users. It is content-independent i.e. it relies on connections only. Since in CF people makes explicit ratings, so real quality assessment of items are done. It provides accurate recommendations because recommendations are base on users similarity rather than items similarity. The optimized matrix are the input to this module. The Updated movie rating matrix from rating optimization module will be given as input to this recommendation module. Movie type matrix is also given as input to the module. Recommendations are made by using collaborative filtering technique based on this updated movie rating matrix and genres of movies.

#### E). Proposed system design

The complete system design of proposed recommendation system is shown in figure 3.1. This system includes three modules. They are dataset preprocessing module, rating optimization module and movie recommendation module.

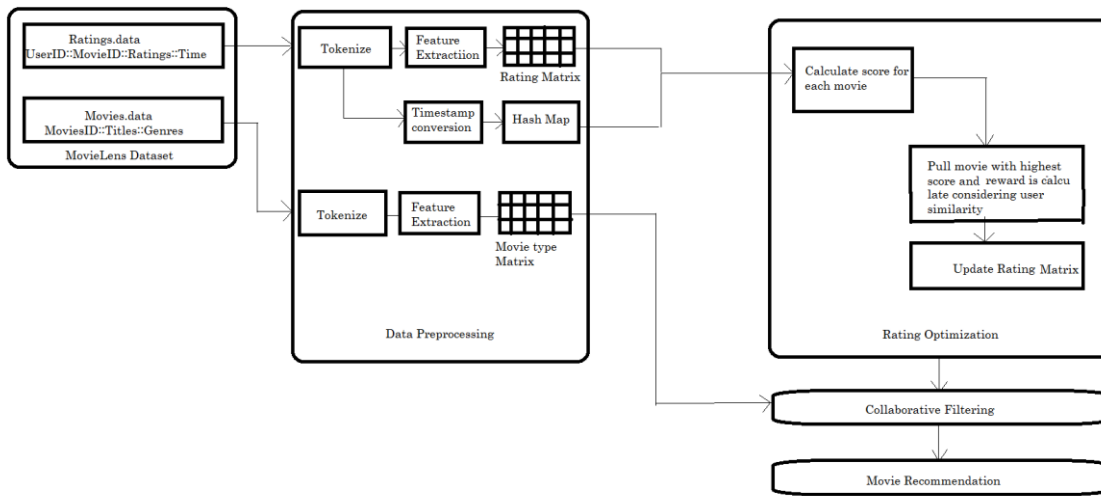


FIGURE 1: SYSTEM DESIGN

#### IV. EXPERIMENTAL RESULTS

The purpose of this section is to validate the effectiveness of implemented recommendation algorithm using time varying multi armed bandit algorithm along with CF. The result analysis is carried out in three phases. They are

- Recommendation accuracy analysis
- Response time-performance analysis on CF algorithm and time varying multi armed bandit along with CF algorithm for movie recommendation.
- Item coverage analysis.

A). Accuracy comparison

Two algorithms, CF algorithm and CF along with time varying multiarmed bandit algorithm are implemented for movie recommendation. Accuracy of movie recommendations on both algorithms are compared here. MovieLens is the dataset used. 30 users are selected randomly and these users are registered to the implemented system. Then these

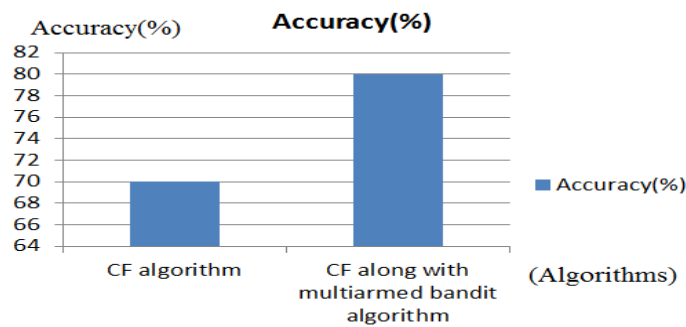


FIGURE 2: ACCURACY ANALYSIS

users are asked to login to their system and checks that whether they are satisfied or not with the given recommendation. This is carried out by means of survey method. Thus the recommendation accuracy of two algorithms are calculated. The graphical representation of recommendation accuracy is shown in figure 2. In the graph, the X axis shows the two different recommendation algorithm and Y axis represents the percentage of recommendation accuracy. Here the traditional CF algorithm have a recommendation accuracy. of 70 percentage and CF along with multi armed bandit algorithm have a recommendation accuracy of 80 percentage. So recommendation accuracy is high for the implemented system than the existing system. The reason for change in recommendation accuracy is due to the presence of rating optimization algorithm in proposed algorithm. The preference of movies and users may varies due to



change in time. So the rating values of each movies may also vary with time. These rating values are updated in movie rating matrix for the purpose of movie recommendation.

B). Response Time - Performance Analysis

The time taken to get recommendation from start of algorithm is analyzed in this section. Time of both CF based recommendation system and CF along with time varying multi armed bandit based recommendation system is analyzed. Response time is the actual time taken to give recommendations from start of a program. In other words, it is the difference between the time at which a task finishes and time at which task starts. The formula for calculating response time is given below.

• Response time = (End time - Start time)

The graphical representation is shown in the figure 3. The Y axis represents the CF based recommendation takes 4.5 minutes to get recommendation and have a recommendation accuracy of 71 percentage. CF along with time varying multi armed bandit algorithm take almost 5 minutes to get recommendation and have a recommendation accuracy of 80 percentage. Even though implemented system takes more time, it has high recommendation accuracy compared to CF based recommendation system. The graphical representation is shown in the figure 3.

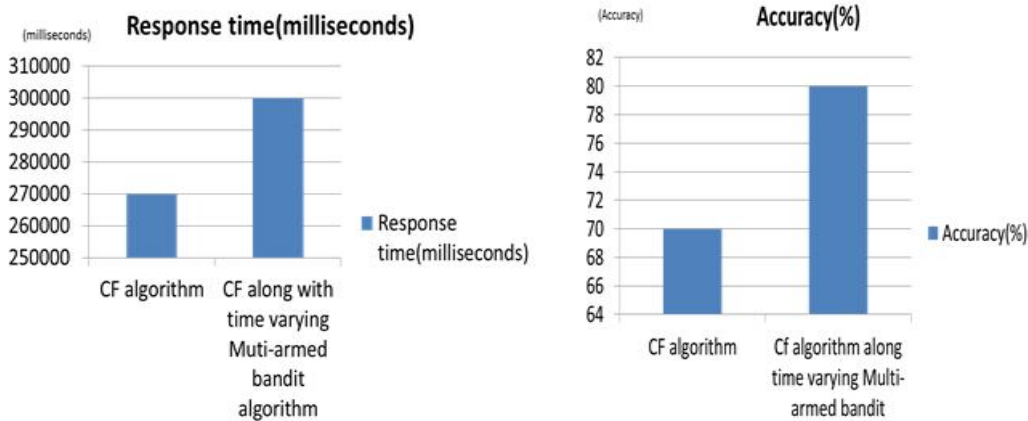


FIGURE 3: RESPNSE TIE ANALYSIS

C). Item coverage analysis

Item coverage measures the percentage of items for which a recommendation system can provide prediction. ie, number of items for which a recommendation system can generate prediction for a given active user over total number of items for same user. Low item coverage indicates that recommendation system will not be able to assist the users with many of items he has not rated. The item coverage values of both traditional CF algorithm and CF with multi armed bandit algorithm are analyzed here in figure 4

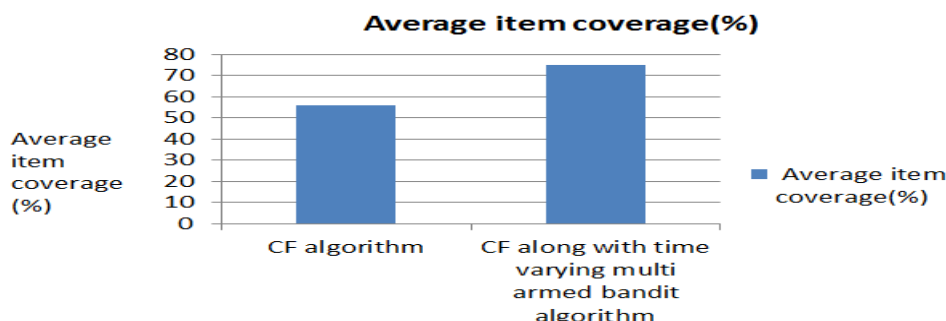


FIGURE4: ITEM COVERAGE ANALYSIS

## V. CONCLUSION

This is an interactive collaborative model for movie recommendation that adopts a generative process based on topic model to explicitly formulate the arm dependencies as the clusters on arms, where dependent arms are assumed to be generated from the same cluster. When an arm is pulled or a movie is picked up, then reward is given to each movie as rating. The latent cluster parameters further help with the reward prediction for other arms in the same cluster. We conduct empirical studies on a real-world dataset including movie recommendation, and the experimental results demonstrate the effectiveness of our proposed approach. Individual preferences on movies usually evolve over time. So this system also focuses on time varying preferences. CF along with time varying multi armed bandit algorithm have high recommendation accuracy compared to CF based recommendation system.

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