Performance Analysis of Back propagation Network Model for Personalized Recommender System

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Abstract- A real world challenging task of an e-commerce application is to identify the needs of the active users based on user navigation patterns. Online navigation patterns are grown every day and extracting business intelligence is a challenging one. There are various personalized recommender systems have been proposed in the literature. In this paper we propose and analyse the performance of back propagation neural network model for personalized recommender system for better quality in terms of accuracy. The performance of an algorithm has been tested with different parameters with real world dataset for the performance benchmark.

Index Terms- Business intelligence, Back propagation, Clustering, Data mining, Recommender system, Personalization.

I. INTRODUCTION

With the gradual increase of customers and products in electronic commerce systems, there is a requirement of efficient personalized recommender systems. Personalized recommendation systems can help people to find interesting things and they are widely used with the development of electronic commerce. Many recommendation systems employ the collaborative filtering technology, which has been proved to be one of the most successful techniques in recommender systems in recent years [14]. These systems are developed for movies, books, communities, news, articles etc. In general, there are five types of recommendation systems [12]. They are collaborative filtering, content based, demographic and utility based systems.

Neural Networks plays vital role in recommender systems to identify missing values from the dataset and to identify user's navigation patterns and classification. It has many advantages like robust in noisy environments, high degree of accuracy, improves its performance by learning, parallelized, low error rate. Hence in this work, back propagation neural network approach has been proposed and analysed for personalized recommender systems which outperform in accuracy.

II. RELATED WORKS

Reports on work in progress related to applying data clustering algorithms to ratings data in collaborative filtering is presented [13]. They use existing data partitioning and clustering algorithms to partition the set of items based on user rating data. Predictions are then computed independently within each partition. Ideally, partitioning will improve the quality of collaborative filtering predictions and increase the scalability of collaborative filtering systems. They report preliminary results that suggest that partitioning algorithms can greatly increase scalability, but they have mixed results on improving accuracy. However, partitioning based on ratings data does result in more accurate predictions than random partitioning, and the results are similar to those when the data is partitioned based on a known content classification.

The performance comparison between multi-layer perceptron (back propagation, delta rule and perceptron) is presented [18]. The author investigates the performance of three algorithms to train MLP networks. It was found that the back propagation algorithm are much better than others algorithms.

Due to its time efficiency, clustering is often applied in mobile phone RS. An example is recommendation system for tourists [7] where clusters are built on users sharing similar interests. Data are taken from registering forms and partitioned using k-means algorithm.

An efficient recommender system using collaborative filtering mechanism with k-separability approach for web based marketing [17]. Author follows the collaborative recommender method in which a user rating is aggregation of various characters using matrix but dataset becomes very noisy and difficult to separate. So, the K-Separability approach extends linear separability of data clusters into k>2 segments on the discriminating hyper plane. It can be implemented by single layer or 2-layer perceptron.

This article presents a solution of recommender system which helps users to select an interesting product [8]. The system analyses data from other customers' ratings of the products. It uses clustering methods to find similarities among the users and proposed techniques to identify users' profiles. The system was implemented in Apache Mahout environment and tested on a movie database. Selected similarity measures are based on: Euclidean distance, cosine as well as correlation coefficient and loglikehood function.

In [6] author introduces a novel collaborative filtering recommender system for ecommerce which copes reasonably well with the ratings sparsity issue through the use of the notion of selective predictability and the use of the information theoretic measure known as entropy to estimate the same.

III. NEURAL NETWORK

Neural network refers to the information processing systems or computer software system that can simulate the structure and function of the biological brain [9]. It is nonlinear complex

network system consisting of a large number of processing units that are similar to neurons. The structure of neural network is determined by the basic processing unit and their inter-connection methods. The field of neural networks may be thought to be related to artificial intelligence, machine learning, parallel processing, statistics, and other fields. Thus, this approach follows the steps to identify users' behavioural pattern and recommends N products by using neural network learning model.

A. Self-Organizing Map

Neural networks that use unsupervised learning attempt to find features in the data that characterise the desired output [21]. They look for clusters of like data. These types of neural networks are often called self-organizing neural networks. Self-Organizing Map [1] is a kind of unsupervised learning technique of Neural Networks which helps in reducing the high dimensional data into low dimensional data and visualizes that.

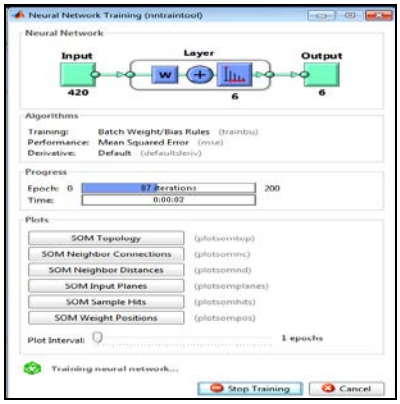

Figure 1 SOM Training State

B. Back-Propagation Network

A Back-Propagation Network (BPN) is a neural network that uses a supervised learning method and feed-forward architecture. A BPN is one of the most frequently utilized neural network techniques for classification and prediction [2] and is considered an advanced multiple regression analysis that can accommodate complex and non-linear data relationships [3]. It was first described by Werbos et al. [4], and further developed by Ronald et al [5]. In this work Self Organizing Map (SOM) neural network is used to cluster the users. Back propagation Network (BPN) is used to identify active users matching cluster for generating recommendations.

IV. PROPOSED METHODOLOGY

This back propagation network approach has four phases. Firstly pre-process the dataset by using feature selection methods and rules to overcome the scalability problem. Secondly clustering is applied, to identify the user navigation behaviour patterns from the given dataset based on the similarity of users. Thirdly, classify the active users matching pattern. Finally obtain intelligence from the patterns for better decision making process to the businesses such as generating recommendations for the active users.

A. Feature selection

Feature selection and reduction techniques reduce the dataset size by removing irrelevant or redundant features. These techniques are used to find the minimum set of features required to create mining models. It reduces number of features in the patterns to understand the patterns easier. Heuristic methods such as step-wise forward selection, step-wise backward elimination, combining forward selection and backward elimination, Principle Component Analysis (PCA) and decision tree induction can be used for selecting the relevant features.

B. Filtering

Filtering helps you create mining models that use subsets of data in a mining structure for scalability. One can create filters use constrains to use only a part of the data for training and testing a variety of models for subset selection. In e-commerce recommender system filtering of users in the dataset is based on knowledge /profile of users defined in terms of rules to reduce the dataset.

C. Clustering to identify users Navigation Patterns

Clustering is applied to identify users navigation patterns. There are various types of clutstering has been proposed in the literature. In this work neural network based Self Organizing Map (SOM) clustering is used to cluster users. Self-organizing maps learn to cluster data based on similarity and topology. The basic SOM model consists of two layers, an input layer and an output layer. The process of SOM is as follows:

1. Assign random values to weight vectors W of a neuron.
2. Provide an input vector D`` to the network
3. distance between weight vector W and input sample D`` is calculated
4. Traverse each node in the network and select the minimum distance neuron
5. Update the nodes in the neighbourhood
6. Iterate from step2 until stopping criterion is satisfied.

The advantage of SOM clustering is stability and convergence assured.

D. Identifying best matching pattern of active users

Back propagation neural network is used to classify active user's best matching patterns because of its improved performance accuracy. Normally there are three types of back-propagation training algorithms. They are Levenberg-Marquardt, Conjugate gradient and resilient back-propagation algorithms. Among these algorithms resilient back-propagation algorithm is faster than the standard deepest algorithms. It also requires modest increase in memory requirements and less impact of parameter settings. Hence in this work, resilient back propagation neural network is used to identify matching patterns of active users.

E. Generation of Recommendation List

Once the best matching patterns are identified the recommendation list can be generated. The recommendations list is generated from the identified user's user navigation behaviour patterns, According to the navigational behaviour pattern of items, this algorithm generate N items as recommendation that have not yet been purchased by the active users.

*F. Algorithm: **KBSOMBPN***

// Algorithm for BPN model

Input:
The number of clusters k.
D = {s_1, s_2, s_3,…,s_{ns}} // Train data
TD=AU= {s_1, s_2, s_3,…,s_{nts}} //Test data
Output:
A set of clusters C_k;N Recommendation List
Begin
1. // Feature selection
   a. $R = r_l = \{x/x \in A, x \geq v_1 \text{ and } x \leq v_2\}$, where l = 1 to nfr
   b. $A' = \sum(a'_j) \bowtie \sigma(a_i(A)/D)$, where i = 1to nf; j = 1 to nsf
   c. D`=$\sum(A') = \{a'_1, a'_2, a'_3, \dots, a'_{nsf}\}$
2. // Filtering of samples
   a. $R = r_l = \{y/y \in D', y \geq v_1 \text{ and } y \leq v_2\}$, where l = 1 to nsr
   b. $D'' = \sum(s_j) \bowtie \sigma(s_i/D')$, where i = 1 to n; j=1 to nss
3. Clustering of users in D'' using SOM
   a. Create self organizing map by randomizing weight vectors W
   b. Select the input D''
   c. Traverse each node in the map
      i. Calculate the similarity between input vector D'' and weight vector W using Euclidean distance
      ii. Find the node with smallest distance(best node)
   d. Update the nodes weights of best node and neighbors
   e. Repeat until converge
4. Classify-using-BPN()
5. Identify frequent items of matching cluster users from $(a_{ij}(A')/D'')$
6. Generate N recommendations on Test set TD
7. Validate Recommendations.

End

Algorithm 2: Classify-using-BPN()
Input:
Cluster of samples
Test set TD of Active user AU
Output:
Identified matching cluster
Begin
//Find the matching cluster C_i of Active Users AU
Initialize all weights and biases in network
Repeat
for each training tuple X in Training set do
Propagate the inputs forward D''
- for each input layer unit
- for each hidden or output unit

Back propagate the errors
- for each unit in output layer
- for each unit in the hidden layers
- for each weight in network
- for each bias in network

Until termination condition is satisfied
Calculate the Performance Metrics on the Test Set TD.
End

This algorithm has been experimentally simulated and evaluated with different real-time datasets with different active users profile and preferences.

V. EXPERIMENTAL EVALUATIONS

Active users knowledge such as user profile and preferences are consider as rules for selecting the features. Different active users profile with various types of preferences defined in terms of rules are analysed for evaluating performance of this algorithm.

A. *Movielens dataset*

MovieLens data set collected by the GroupLens Research Project is used to test the performance of this proposed algorithm [19]. The GroupLens Research Project is a research group in the Department of Computer Science and Engineering at the University of Minnesota. Members of the GroupLens Research Project are involved in many research projects related to the fields of information filtering, collaborative filtering, and recommender systems.

This data set consists of 100,000 ratings (1-5) from 943 users on 1682 movies. Each user has rated at least 20 movies. The data set was converted into a user-movie matrix R that had 943 rows (users) and 1682 columns (movies that were rated by at least one of the users).The dataset features are normalized between 0 and 1.Simple demographic information about the users is age, gender, occupation, zip. This has 5 disjoint sets with 5 fold cross validation. There are some real-world datasets such as Jester and e-commerce are also available on the web site for recommender systems.

B. *Evaluation Metrics*

We have evaluated the results of tests of the machine learning algorithms on the MovieLens dataset by using evaluation metrics like Silhouette index (SI), Measure Absolute Error (MAE), recall, precision, and F1 Measure.

C. *Experimental Setup*

All our experiments were implemented using MatlabR2013a. We ran all our experiments on a Windows 7 Home Basic based PC with Core i3 processor having a speed of 2.40 GHz and 3GB of RAM.

VI. EXPERIMENTAL RESULTS

In this section we present detailed experimental results of the proposed algorithm and compared its performance with different metrics. Firstly the quality of the clustering is evaluated using Silhouette Index measure. Second the prediction evaluation result using Total Mean Absolute Error (TMAE) is calculated. Finally recommendation generation is evaluated using recall, precision and f1 measure.

A. *Clustering Quality Evaluation Results*

We examine the influence of various cluster number k on clustering validity. The optimum number of clusters can be determined by testing various numbers of clusters and its silhouette measure. Figure 2 shows the silhouette measure value calculated using various number of clusters k.

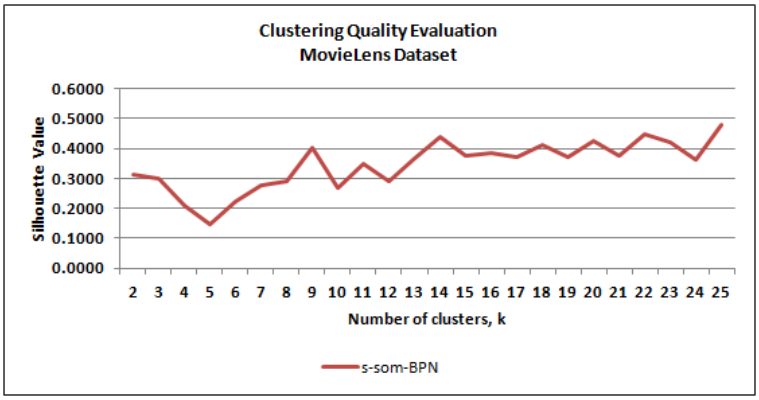

Figure 2 : Clustering Quality Evaluation

B. *Prediction Evaluation Results*

We simulated the algorithm with various train data and test data to compute the Total Mean Absolute Error (TMAE). Figure 3 shows the accuracy of prediction calculated using accuracy measure TMAE.

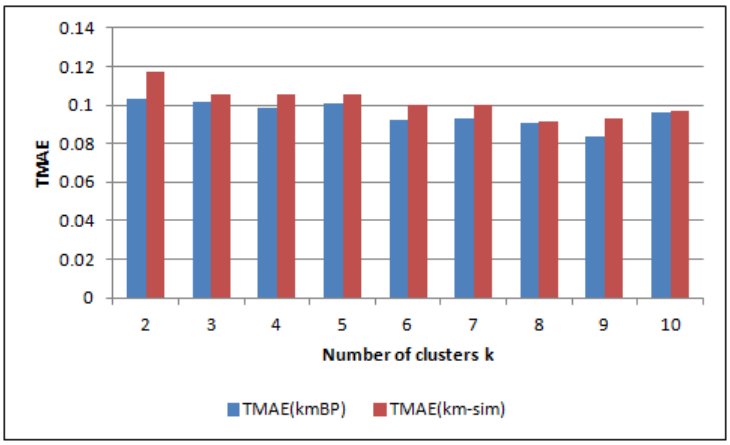

Figure 3. Accuracy of similarity matching

It can be observed from the results that average for back propagation similarity computation has a clear advantage, as the MAE is significantly lower in this case.

C. *Recommendation Evaluation Results*

We used different number of recommendations to evaluate the recommendations. Figure 4 shows the influence of number of recommendation on recall and precision measure.

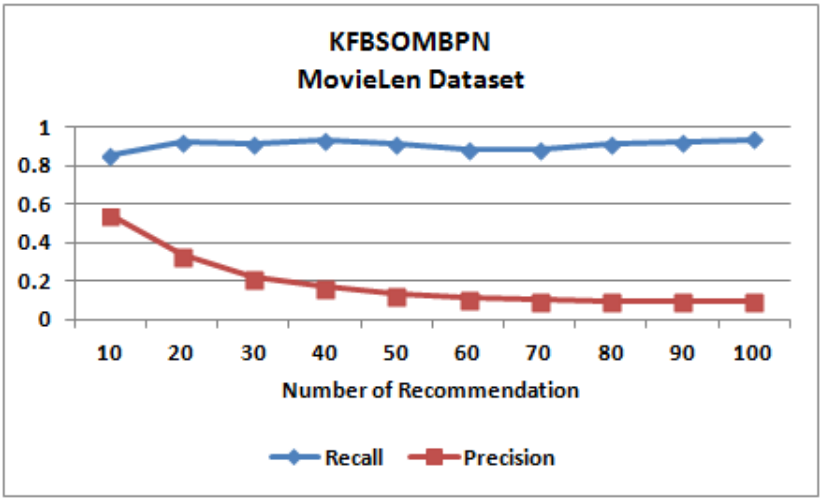

Figure 4 Number of Recommendation vs. Recall vs. Precision

Figure 5 shows the influence of various numbers of recommendations on F1 measure.

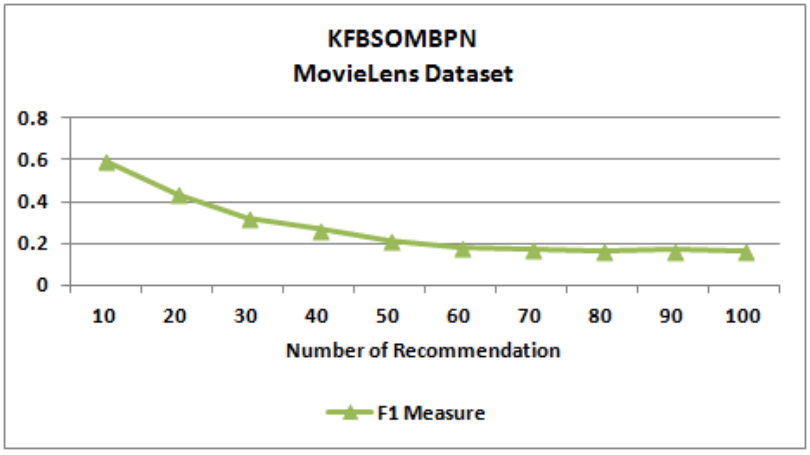

Figure 5 Number of recommendations vs. F1 measure

The simulation results show that proposed algorithm is performing well in terms of accuracy in matching the active user's cluster and recommendation quality.

VII. CONCLUSIONS

The proposed approach utilizes the knowledge filtering, clustering and back propagation neural network classification to produce the recommendations. The performance of the algorithm has been tested with various parameters such as number of clusters, dimensions and N recommendations. The results from various simulations with real world movielens dataset show that recommendation generated by this algorithm is more scalable and accurate.

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