International Journal of Informatics and Information System ISSN 2579-7069
Vol. 2, No. 2, September 2019, pp. 91-98

Improving Music Recommendation System by Applying Latent Topics of Lyrics

Khine Zar Thwe [1,*], Takashi Yukawa [2]

[1] Nagaoka University of Technology, Japan
[1] s155069@stn.nagaokaut.ac.jp*; [2] yukawa@vos.nagaokaut.ac.jp;
* corresponding author

Abstract

The proposed music recommendation system was developed by using various information filtering approaches based on user context and song context. This study proposes a music recommendation system with Latent Dirichlet Allocation (LDA) by using user listening behavior and analyzing a latent relationship of each song. As a consequence, small musical niche genres without listing history will become a member of their respective topic groups. Modeling topic analysis of LDA is utilized for songs lyric as well as the user action and, then song group preferences support the collaborative filtering recommendation engine. The system addresses the optimization of the cold start problem of adding new items in Collaborative Filtering by lyric analysis with LDA. Predicted ratings for user recalculated by combination matrix of song listening action with binary rating values and latent topic group result of lyrics. In this analysis, a system proposition compared with two models, normal collaborative filtering and user defined genre group preference.

Keywords: Recommendation System; Collaborative Filtering; Lyrics, Latent Dirichlet Allocation; Multimedia Web Application;

1. Introduction

Due to the continuous development of world-wide-web technology, continuous improvement of data sources and the enormous growth of information over the Internet, most of the people are spending their time on the Internet not only for their personal purposes but also for sharing and storing knowledge. A large amount of resources approaches the problems of divergence between desired information and retrieved information for end users. User's knowledge , limited restrictions and user information processing ability might be one kind of reason for information overload problems. Moreover, the competitive emergence of e-commerce research has led to the development of recommendation systems and personalized information filtering techniques. All research work provides contributions not only for end user's satisfaction but also for significant business impacts.

The Recommendation System identifies and suggests the set of items by tracking users' behaviors or their preferences of personalized information. Recommended songs provided by the YouTube video website, recommended items provided by amazon website are typical examples for recommendation systems. There are basically three types of recommendation system algorithm: content-based filtering techniques, collaborative filtering techniques, and hybrid filtering approach. Collaborative filtering [8] approach, the most successful technology because of its serendipity result for end users, bases its recommendations and predictions on the ratings or behavior of neighbors users in the system. This approach is widely used in various domains such as document recommendation, music recommendation and video recommendation and others e-commerce domains.

This study emphasizes the recommendation system on the music domain. Traditional music recommendation systems are widely used collaborative filtering because ofits effective performance. A good music recommendation system can be built by researching how to relate various songs, artists and users and then providing the suitable recommended songs for a certain user. Collaborative filtering provides good performance for the user if it has sufficient historical datasets. It encounters the cold start problem which occurs when there is no enough user input or no user input. In recent research work, researchers address a hybrid approach by combining content-based filtering with collaborative filtering [16] [17], to minimize the drawback of each collaborative and content based filtering

techniques. The meaningful characteristic of user's content plays a vital role to provide the weakness of collaborative filtering. But collecting meaningful users content is the big challenge in the development phase. In this regard, our approach is only to focus on collaborative filtering and try to reduce its drawback, cold start problem, by applying latent relationship between the songs with text mining techniques called Latent Dirichlet Allocation (LDA).

This research proposes a common recommendation system based on user listening behavior and support relationship results by lyric analysis of LDA. The main objective of the system is to initiate the group values are considering in item * item collaborative filtering. And then reduce the cold start problem of collaborative filtering by analyzing the latent structure of lyrics by using LDA. In text mining fields, Latent Semantic Analysis was introduced for finding the latent relationship between the documents. Followed by probabilistic latent semantic analysis (pLSA) and LDAis arose by serving to automatically analyze and visualize the latent structure of each document's topics. In our investigation, we assume the song lyric as a document structure and apply the LDA algorithm to define the topic of the song group over the average topic document (lyric text) probability result by each song. Proposed system optimizes the cold start problem of normal collaborative filtering technique without adopting hybrid technique. The rest of the paper will present as followed: Section 2 reviews related works. Section 3 introduces our proposed approach. Implementation and corresponding evolutions presented in Section 4. Section 5 addresses the opinion by reasoning, research limitations and future work.

2. Related Works

2.1. Recommendation Filtering Techniques

Giving a general panorama of past to present enhancement of recommendation principles, these are categorized into three fundamental filtering techniques: content-based filtering, collaborative filtering and hybrid filtering techniques. Although these techniques have advantages and disadvantages, they all focus on providing good and useful recommendations to its individual users. All research targets to reduce the disadvantages of each system by their specific proposed methods. Content-based filtering (CBF) techniques calculate the recommendation based on user profiling from the content of items that are positively related from the past. User profiling in content-based filtering includes users' needs and preferences and items that can indicate a high similarity are chosen as recommended items.

Different from the former one, recommended items in Collaborative filtering (CF) techniques were built on the ratings of the items or behavior of other users' preference in the whole system. Firstly, construct the user * item matrix (preference for items by users), and then select the neighborhood group (by items or by users) and finally calculate the predicted rating and recommendation with its defined equations. In this way, traditional collaborative filtering employs user-user collaborative filtering (user-based) and item-items (item-based) collaborative filtering. In order to gain better system optimization and to avoid the system limitations problem of traditional recommendation systems, Hybrid approach is developed by combining CBF and CF to implement each other. Hybrid combination can be classified into the following ways [6]: implement the system separately and aggregate the result, Employ CF features into CBF approach, employ CBF features into CF approach, create a unified model that brings together both approaches. The following figure shows the summary of traditional recommendations filtering techniques.

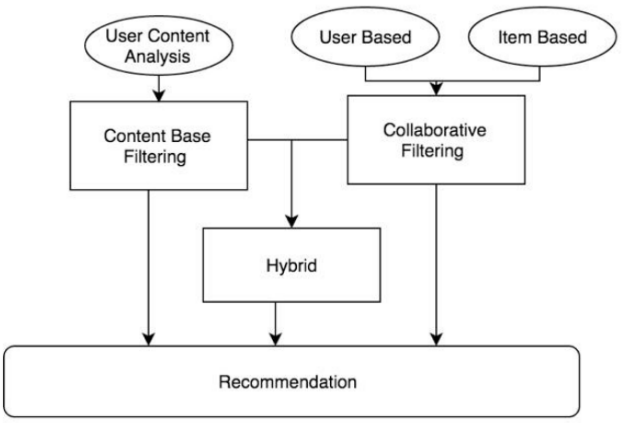

Figure. 1. Recommendation Filtering Techniques

Although item rating was used for calculation predicted rating in collaborative filtering, Jorge et al. [1] investigated collaborative filtering with binary rating. They evaluated non-incremental and incremental item-based algorithms as well as incremental user-based algorithms and finally observed that recall and precision trend to improve by testing with three types of dataset. Gossi et al. [5] studied the content-based music recommendation system based on lyrical data. To reduce the cold start problem in collaborative filtering, they use content-based lyrical recommendation and prove that their studies are better than normal CF filtering.

2.2. Latent Topic Modeling and current researches

Early research works in information retrieval (IR) for text corpora include the tf-idf scheme, that reduces each document in the corpus to a vector. The basic popular information filtering, information retrieval method, vector space model use tf-idf score for extracting queries from text corpus. It had limitations on inter-and intra-document similarity, so that IR researchers have proposed a notable model, latent semantic indexing (LSI). LSI is a method for discovering hidden concepts in document data by using Singular Value Decomposition. Based on LSI one of the approaches called Latent Dirichlet Allocation (LDA), a common topic modeling technique, was investigated by David Blei et al. [4]. It is a way of automatically discovering topics that these sentences contain in documents. Even though the air research based on text mining, LDA was applied in different types of fields such as bio-informative, content based image retrieval and etc.

Te-Min Chang et at. [16] [17] studied hybrid filtering Document Recommendation by using LDA with two approaches (personalized and group). Before performing the hybrid filtering techniques, the LDA model was used to analyze and categorize the latent semantic structure among the collected documents and to serve as a bridge. to connect CBF and CF. They proved that the group preference with LDA analysis is better than item-based collaborative filtering.

Taking the advantages of LDA, Sasaki et al [14] developed lyricsrader: one kind of music retrieval system based on latent topics of lyrics. Topics of lyrics were automatically analyzed and visualized by LDA and provided the user for pentagon-style shape topic radar charts based on their target lyrics. Likewise, Brynjar et at. [2] demonstrated a system called TopicNets: a system that enables fast discovery of information that is hard to find, visual analysis of large text corpora by using topic modeling.

Sung Eun Park et at. [15] developed Session-Based Collaborative Filtering (SSCF) for music recommendation system without taking the user's previous preference. By tracing a set of item sessions (song listening sessions) and predict the next sessions for specific users and prove that SSCF possesses better recommendation accuracy than normal CF. Based on SSCF research, Ricardo Dias et at. [13] studied improving music recommendation based on SSCF by using temporal context. Like previous works, song listening sessions were taken as item preferences and sessions are grouped by dividing different features (different usage time) named temporal context. Taking the session as a document, songs as word and use LDA to describe the session as topic distribution and prove that they possess better accuracy than traditional session-based CF methods. Their studies highlight the cold start problem and solve this weakness without taking user content preferences.

There are many different approaches that have been proposed to improve the music recommendation result with LDA. Apart from other research, we attempt to group songs by topic distribution and support these pre-process results to item collaborative filtering for the purpose of reducing item cold start problems.

3. Proposed Approach

Our empirical investigation focused to propose item based collaborative filtering approach by grouping the songs. Pure Collaborative filtering considers the item rating (song rating) and user behavior (song listening behavior) for predicting and recommending to users. Our proposed system brings a grouping result by lyrics analysis with LDA to user listening actions, uses incremental collaborative filtering with binary rating (Jorge et al. [1]) for calculating predicted rating. Instead of grouping song by song genre, the algorithm applied in the study, LDA, is used for grouping the songs. To be simplicity and to compare with the result by genre group, the topic number was set to ten. Genre Classification research [3] is one of the validation of the relationship between genre and LDA topic groups.

Normal collaborative filtering takes the item rating preference and user behavior. When the new items which is no rating and no history will not be considered as similar result, therefore, these items will become cold items. Genre

groups preferences are contemplated in some research works. At that point, niche genre groups are transformed into cold item groups. We found that niche genre groups are dissolved in topic groups by lyrics analysis with LDA. The proposed music recommendation system referred to lyric analysis, so that song grouping by LDA is the most frequent step before we implement the recommendation engine.

3.1. Lyric Analysis By LDA and Recommendation Model

LDA is unsupervised learning and hence it assigns each word to reasonable topics for each song autonomously. When we collected the songs, we also crawled the lyrics from free lyric websites.Initially, we constructed a simple lyric corpus. When the user uploads the songs, cleaning the lyric text stemming, removing stop words and lyrics words (observed words) are automatically added to the existing corpus. And then topic modeling with LDA rearrange the topic distribution to songs in the system. grouping the songs. Each song possesses a different topic proportion values for each topic group. The song belongs to the group for which it has the highest topic proportion.

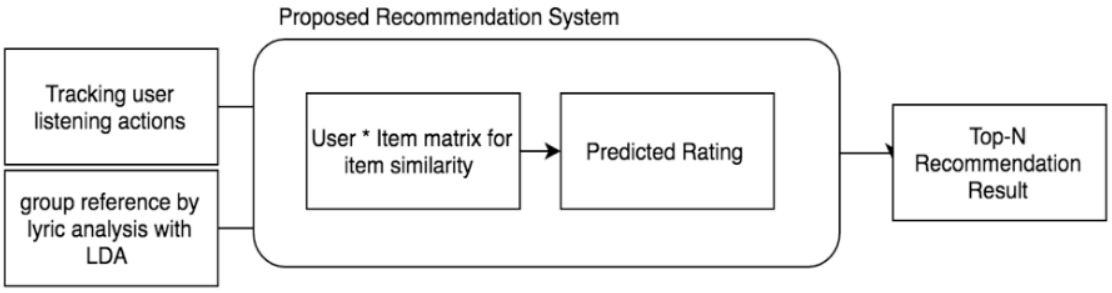

Figure. 2. Proposed Recommendation System

Proposed item-based collaborative filtering recommendation system, firstly find the similar item that the user listened and uploaded. Building the user-song binary rating matrix by using user listening behavior, if the user listens to the song, the value will be 1, otherwise 0. As an addition, group reference values judge the user-song rating matrix. Jaccard Similarity was used for measuring song similarity results. Can be calculated by dividing the intersection result between these two items with the union result of these two items.

$$sim(i,j) = \frac{|i \cap j|}{|i \cup j|}$$

Predicted rating of normal Item-based collaborative filtering is calculated by using rating values and similarity of the items. Alternatively, one of the implicit feedbacks, user listening behavior is utilized as a binary song rating, and item similarity is employed in the proposed recommendation system. The predicted rating formula for proposed approach as can be defined as follows:

$$P_{u,i} = \frac{\sum_{j \in N} sim(i,j) \cdot r'_{u,j}}{\sum_{j \in N} |sim(i,j)|}$$

with respect to {if ru,j=0 and gi,jis 1,then r'u,j=1}

Pu,j stands for predicted rating for user u for item i, Refers to total number of items and sim(i,j) is the item*item similarity result. ru,jis the user listening and uploading actions. gi,jvalues are the resultant values generated by LDA based on group's preferences from lyric analysis and used to determine the output together with the equation 2. Belong to this equation with proposed system, if ru,j0, system do not need to consider group result gi,j, if the ru,j= 0 and the gi,j is 1, the system changes r'u,j= 1. If the item i and item j are same group, gi,j will be 1 if not the value will be 0.

Finally, Top-N recommendation [10] was employed to set results for the target user.Predicted rating results are estimated primary results for active users. Simply, we sort the descending order and select the first N songs for the recommendation list of active users.

4. Implementation and Evaluation

4.1. Overall System Design

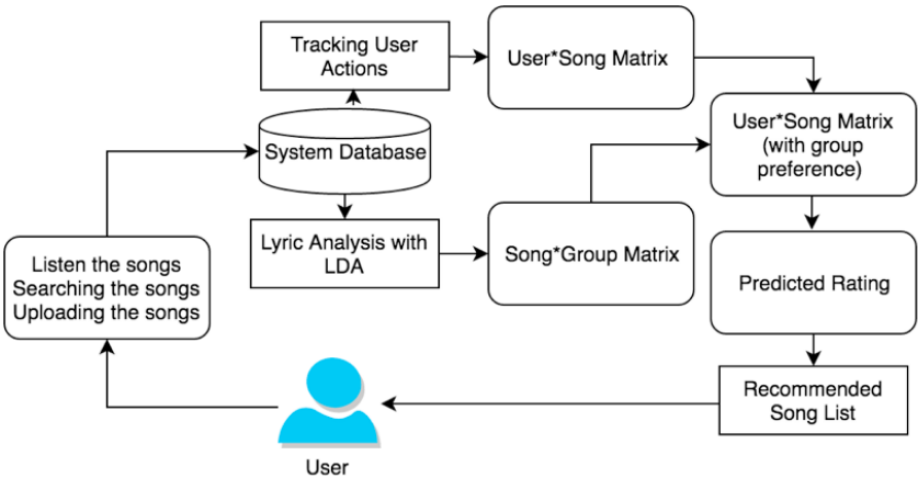

Figure. 3. Proposed System Flow

Figure 3 represents the overall system flow of the proposed music recommendation system. User * Song Matrix was rearranged by combining the song group preferences and User * Song listening action matrix. Song preference group was assigned by average topic document (song lyrics) probability. All user actions were tracked by the system and these are basic criteria for calculating predicted rating for the target user. N number of descending predicted rating values longswere become the recommended song list for target users.

4.2. Experiments and Result

The Proposed system is implemented as a web-based application system. Total number of 12 users and their uploaded over 500 songs are analyzed for the proposed system.In an attempt to identify the topic distributions, lda-ruby 1 gem was chosen to build the LDA model lyric analysis. At first, the proposed system tracks the user action (listening, searching and uploading), and according to the tracking process, recommendation can be calculated.

Reporting results from initial user analysis, Figure 4, shows the result of user's song listening behavior which observations that user list not only their favorite genre but also other genres. Because of this analysis, to reduce the cold start item and cold start genre group, LDA group reference values are developed into the proposed system.

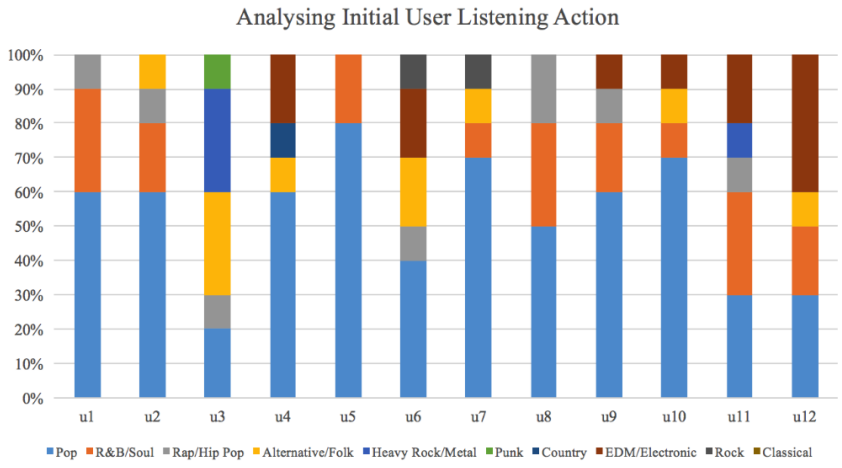

Figure. 4. User Listening Action by Genre

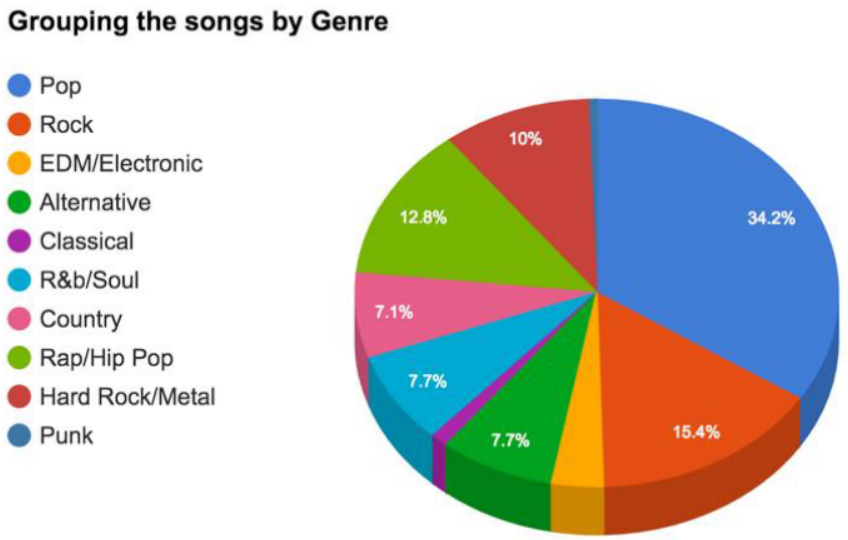

Figure. 5. Song Group by Genre

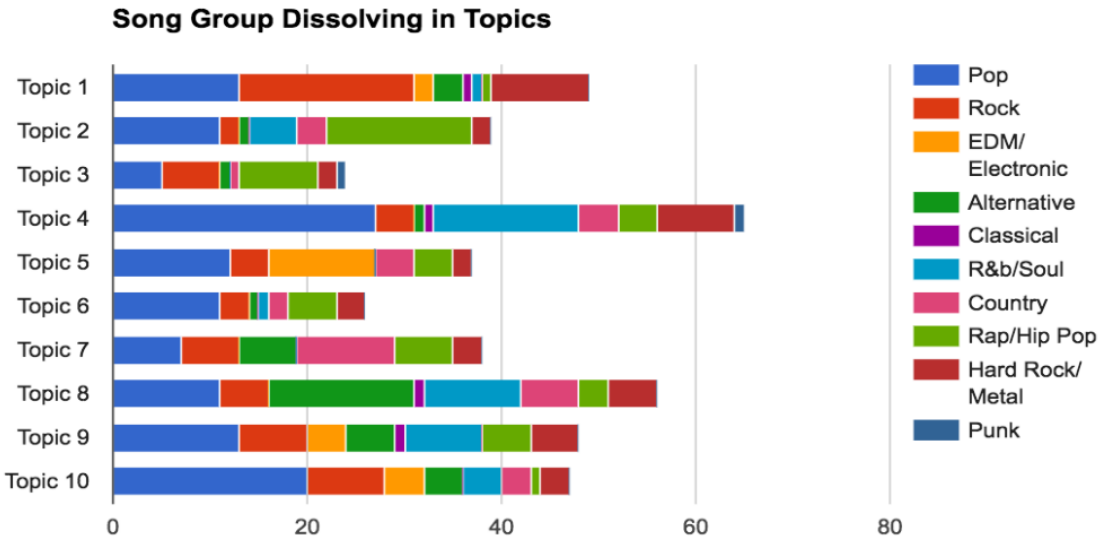

Figure. 6. Song Genre dissolving in topics

Data categorical results, grouping song data with genre preference shown figure 5.Inthegroup preference of genre approach, system channel generates serendipity result when the user listening history has only one niche group. Figure 6 describes the result of LDA preferences with lyrics applied for grouping songs, we can see that songs are interestingly dissolved in their respective latent topic groups results. For example, niche genres (punk, classical) are combined to topic 3,4 and 1,9. In addition, normal collaborative filtering, genre group based collaborative filtering was conducted to examine and compile the results of our proposed approaches.

4.3. Evaluation

The first step of an evaluation is to define system goals as precisely as possible [7] [11]. In our research, evaluation was divided into two parts. Firstly, precision value adopted to measure the recommender performance. Precision values or true positive accuracy can be calculated by the ratio of recommended items that are relevant to the total number of recommended items. High precision value refers to better recommendation accuracy. Precision values for recommendation system can be expressed as follow:

$$Precision = \frac{correctly\ recommended\ items}{total\ recommended\ items}$$

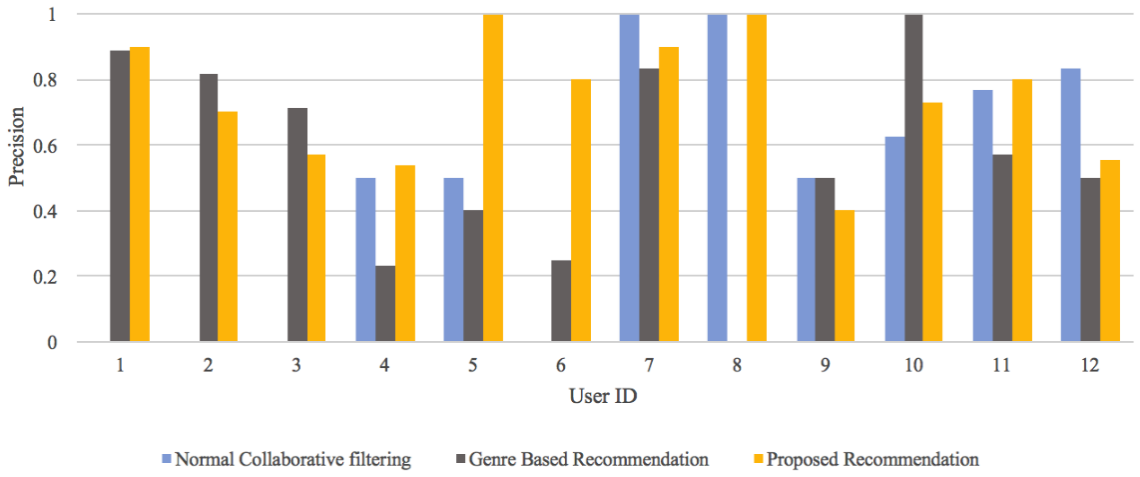

Figure. 7. Precision Performance with three Experiment

Testing the three approaches with the same data and same users, the result of precision values was illustrated in figure 7. Collaborative filtering approach depends on the sufficient historical dataset. We can see in the graph, that a normal CF approach cannot generate the result to some users. So that precision values will become 0 in these cases. However, the group preference methods, genre based recommendation and proposed approach can generate recommended songs for the user without having the sufficient history dataset.

Because group preference methods set "1" to categorical group values that are the same with current listening groups. Grouping the songs with the latent relationship between the songs by LDA have the highest average precision values nearly 0.74. Precision results calculated by collecting user feedback from recommended songs. From our experiment, the proposed recommendation system possesses 18% average precision value than the genre based recommendation system and 30% better than normal collaborative filtering.

Table. 1. Net User Satisfaction Result (NSAT)

Very Satisfied Result	Somewhat Satisfied Result	Somewhat dissatisfied Result	Very dissatisfied Result
60	69	19	1
35	34	5	1

NSAT= (VSAT-DSAT) + 100 where VSAT= very satisfied response, DSAT= somewhat dissatisfied + very dissatisfied

Second stage, we collect the survey from user in two parts, measure the quality of recommended items [12] and measure performance of web application in user point of view.Our NSAT (net user satisfaction) [9] amounts to 169by taking the user experience over the web-based application of the proposed music recommendation system. According to the result of table 1, achieving a score (> 100) indicated end-user satisfaction level was higher than dissatisfaction level. Higher values possess better satisfaction with the system.

5. Conclusion and Future Works

Recommender system unlocked opportunities of retrieving personalized information. In this research, we bring music recommendation systems with latent relation groups references. We proposed to utilize a lyric relationship with the LDA and approach to item-based collaborative filtering for recommendation engine. In order to resolve the cold start problem of collaborative filtering methods, usegroup preference and then solve the cold genre group preference with topic group results. Additional two methods are conducted to examine while testing the performance of the proposed approach. significantly higher accuracy than other two approaches.

Although the results of our research seem auspicious, there are several issues that need to be addressed. User * Song matrix in our data characteristics: we use only binary rating instead of original rating scale. Adapting our proposed approaches into existence situations, we need to collect additional data and dataset for examining the feasibility of our proposed approaches under such kinds of cases. users) to our collaborative filtering approach is recommended.

References

[1] Alipio M. Jorge and Catarina Miranda, Incremental Collaborative Filtering for Binary Ratings. IEEE, WIC, ACM International Conference on Web Intelligence and Intelligent Agent Technology, 1 (1), 389-392, December 2008.

[2] Brynjar Gretarsson, John O'Donovan, Svetlin Bostandjiev, Tobias H¨ollerer, Arthur Asuncion, David Newman, and Padhraic Smyth, Topicnets: Visual Analysis of Large text corpora with topic Modeling.ACM Transactions on Intelligent System and Technology (TIST), 3 (2), 1-26, February 2003.

[3] Brandon Chao and Ankit Sirmorya, Automated Movie Genre Classification with LDA-based Topic Modeling. International Journal of Computer Applications (0975-8887), 145 (13), 1-5, July 2016.

[4] David M. Blei, Andrew Y.Ng, and Michael I. Jordan, Latent Dirichlet Allocation, Jouranal of Machine Learning, 3,993-1022, January 2003.

[5] Derek Gossi and Mehment H Gunes, Lyric-Based Music Recommendation. Complex Network VII, Studies in Computational Intellignet, 644,301-310,2016.

[6] F. O. Isinkaye, Y.O. Folajimi, and B.A. Ojokoh, Recommendation System: Principle, methods and evaluation.Egyptian Information Journal, 16 (3), 261-273, November 2015.

[7] Gunnar Schroder, Maik Thiele and Wolfgang Lehner, Setting Goals and Choosing Metrics for Recommender System Evaluations, The 5thACM Conference on Recommender System, October 2011.

[8] Micheal D. Ekstrand, John T. Riedl, and Joseph A. Konstan, Collaborative Filtering Recommender Systems, Foundation and Trends in Human-Computer Interaction, 4 (2), 81-173, May 2010.

[9] Microsoft, Office 365 User Surveys: Determining Net User Satisfication, url: http: //download.microsoft.com/download/3/2/2/32269687-F181-449A-8C72-317090403C70/Determining_Net_User_Satisfaction.docx

[10] Mukund Deshpande and George Karypis, Item based Top-N Recommendation Algorithms. ACM Transactions on Information Systems, 22 (1), 143-177, January 2004.

[11] Paolo Cremonesi and et al., An Evaluation Methodology for Collaborative Recommender Systems, International Conference on Automated solutions for Cross Media Content and Multi-Channel Distribution, 224-231, December 2008.

[12] Pearl Pu, Li Chen, and Rong Hu, A User-centric Evaluation Framework for Recommender Systems, The 3thACM Conference on Recommender Systems, 157-164, October 2011.

[13] Ricardo Dias and Manuel J. Fonseca, Improving Music Recommendation in Session Based Collaborative Filtering by using Temporal Context. IEEE 25th International Conference on Tools with Artificial Intelligence, 783-788,2013.

[14] Shoto Sasaki, Kazuyoshi Yoshii, Tomoyasu Nakano, Masataka Goto, and Shigeo Morishimi, Lyricrader: A Lyric Retrieval System Based in Latent Topics of Lyrics, 15th International Society for Music Information Retrieval Conference ISMIR, Taipei, Taiwan, 585-590, October 2014

[15] Sung Eun Park, Sangkeun Lee, and Sang goo Lee, Session Based Collaborative Filtering for Predicting the Next Song. Computer, Networks, Systems and Industrial Engineering (CNSI), 365 (1), 353-385, July 2011.

[16] Te-Min Chang, Wen-Feng Hsiao, and Yi-Ling Lin, LDA-Based Group Document Recommendation, PACIS 2014 Proceeding, June2014.

[17] Te-Min Chang and Wen-Feng Hsiao, LDA-Based Personalized Document Recommendation, PACIS 2013 Proceeding, July 2013.