Mathematical Statistician and Engineering Applications
ISSN: 2326-9865
DOI: https://doi.org/10.17762/msea.v70i1.2317

A Multi-Criteria Movie Recommendation System based on User Preferences and Movie Features

Kamred Udham Singh

Asst. Professor, School of Computing, Graphic Era Hill University, Dehradun, Uttarakhand India 248002

Article Info
Page Number: 348-360
Publication Issue:
Vol. 70 No. 1 (2021)

Article History
Article Received: 25 January 2021
Revised: 24 February 2021
Accepted: 15 March 2021

Abstract
In this research, we develop a multi-criteria movie recommendation system that provides personalised recommendations by taking into consideration both user preferences and movie aspects. To get over each method's specific drawbacks, the suggested system takes a hybrid approach that combines collaborative filtering with content-based techniques. The system uses collaborative filtering to capture user preferences based on historical ratings, while content-based methods analyze movie features such as genre, director, actors, and keywords to enhance the recommendation process. Additionally, we integrate various external data sources like movie reviews, social media sentiment, and box office performance to enrich the movie feature set. The system employs a weighted aggregation method to combine these criteria and generate a comprehensive recommendation score. The effectiveness of the proposed system is evaluated utilizing standard metrics including recall, precision, and F1-score on a publicly available dataset. The results demonstrate that our multi-criteria recommendation system effectively captures user preferences and provides more accurate and diverse recommendations compared to traditional single-criterion approaches.

1. Introduction

With rapid growth of internet and proliferation of digital media content, users are inundated with a vast array of choices when it comes to selecting movies to watch. To help users navigate this information overload, movie recommendation systems have become essential tools for providing personalized and relevant suggestions based on individual preferences and tastes. Traditional recommendation systems typically rely on either collaborative filtering or content-based approaches. Collaborative filtering leverages user-item interactions to generate recommendations, while content-based methods utilize the features of items themselves, such as genres and actors. However, each of these techniques has its own limitations. Collaborative filtering suffers from the cold-start problem and data sparsity issues, while content-based methods can be limited by the available information on item features. To address these challenges, we propose a multi-criteria movie recommendation system that combines user preferences and movie features to generate personalized recommendations. Our system employs a hybrid approach, integrating collaborative filtering and content-based methods, to overcome the limitations of each method individually. By utilizing both user-item interaction data and movie feature information, our system is able to generate more accurate and diverse recommendations, improving the overall user experience.

In our proposed system, we first use collaborative filtering to capture user preferences based on historical movie ratings. This allows us to identify patterns in user preferences and make

recommendations accordingly. We then employ content-based methods to analyze movie features, such as genre, director, actors, and keywords. By incorporating movie features, we can provide recommendations that are more closely aligned with user interests, even for new or less popular movies with limited user-item interaction data.

To further enhance our recommendations, we integrate various external data sources, such as movie reviews, social media sentiment, and box office performance. By combining these additional data sources with traditional movie features, we can generate a richer feature set, which contributes to more accurate and diverse recommendations. Finally, we employ a weighted aggregation method to combine the multiple criteria derived from user preferences and movie features. This aggregation allows us to generate a comprehensive recommendation score for each movie, enabling us to rank and present the most relevant suggestions to users.

The remaining portions of this document are structured as follows: In the following section, we will discuss previous research in the topic of movie recommendation systems. In the next section, we will discuss in further depth the technique behind our proposed multi-criterion recommendation system. The system is evaluated in Section 4 using a dataset that is freely available to the public, and the work is brought to a close in Section 5 with a summary of our findings and suggestions for where future research should head.

2. Literature Survey

In this paper, Al-Ghuribi and Mohd Noah [1] present a comprehensive survey of multi-criteria review-based recommender systems (MCRS). MCRS utilize multiple criteria instead of a single overall rating, which provides more accurate recommendations. Authors review in this field by examining various aspects of MCRS, including methodologies, techniques, and evaluation metrics.

The structure of the paper is as described below:

- Introduction: The authors provide an overview of recommender systems and the need for multi-criteria review-based systems.
- Background and motivation: This section discusses the motivation behind MCRS and their advantages over single-criteria systems.
- Multi-criteria review-based recommender system techniques: The authors present different MCRS techniques, such as collaborative filtering, content-based filtering, hybrid methods, and context-aware methods.
- Evaluation metrics: The paper discusses various evaluation metrics for MCRS, such as accuracy, coverage, diversity, novelty, and serendipity.
- Datasets and benchmarking: The authors provide an overview of available datasets and benchmarking methods for MCRS.
- Challenges and open issues: This section highlights the challenges and open issues in MCRS research, such as data sparsity, cold start problems, scalability, and privacy.

- Conclusion: The paper concludes with a summary of the current state of the art and future research directions.

In this work, Faisal, Hameed, and Khattak [2] propose a deep neural network (DNN) based approach to recommend movies to users based on their current preferences. The authors argue that traditional collaborative filtering methods suffer from various limitations, such as data sparsity and cold start issues. By employing a DNN, the proposed approach aims to overcome these limitations and provide more accurate recommendations.

The structure of the paper is as described below.

- Introduction: The authors provide a brief introduction to recommender systems and highlight the challenges associated with traditional methods.
- Related work: This section presents a review of existing literature on movie recommendation methods and DNN-based approaches.
- Proposed methodology: The authors describe their DNN-based approach in detail, including data preprocessing, feature extraction, and the architecture of the DNN.
- Experimental setup and results: This section presents the experimental setup, including dataset, evaluation metrics, and performance comparison with other methods. The proposed DNN-based approach outperforms other methods in terms of accuracy and recall.
- Conclusion and future work: The paper concludes with a summary of the proposed approach and suggestions for future research, such as incorporating contextual information and exploring other DNN architectures.

In this paper, Zhang et al. [3] propose a personalized real-time movie recommendation system, which aims to provide accurate and timely recommendations to users. The authors develop a practical prototype and evaluate its performance through user studies.

The structure of the paper is as described below.

- Introduction: The authors provide an overview of the challenges in real-time movie recommendation and introduce their proposed system.
- Related work: This section presents a review of existing literature on real-time recommendation and personalized systems.
- System architecture and design: The authors describe the architecture of their proposed system, which includes a user interface, a recommendation engine, and a feedback mechanism. The recommendation engine employs a hybrid approach that combines content-based filtering and collaborative filtering.
- Experimental evaluation: This section presents the evaluation of the proposed system through user studies, which show that the system can provide accurate and real-time recommendations.

- Conclusion and future work: The paper concludes with a summary of the proposed system and its evaluation. The authors also discuss future research directions, such as incorporating additional contextual information and improving the scalability of the system.

In this work, Tang et al. [4] introduce a novel method called Cross-Space Affinity Learning (CSAL) for movie recommendation. CSAL aims to discover the hidden relationships between different spaces, such as user-item and item-feature spaces, to improve recommendation accuracy.

The structure of the paper is as described below.

- Introduction: The authors provide a brief introduction to movie recommendation and the motivation behind CSAL.
- Related work: This section presents a review of existing literature on movie recommendation and affinity learning methods.
- Cross-Space Affinity Learning: The authors describe the proposed CSAL method, which is based on affinity learning to discover hidden relationships between different spaces. They explain how the method can be applied to movie recommendation by mapping user-item interactions and item-feature spaces.
- Experiments: This section presents the experimental setup, including dataset, evaluation metrics, and performance comparison with other methods. The results show that CSAL outperforms existing methods in terms of recommendation accuracy.
- Conclusion and future work: The paper concludes with a summary of the proposed CSAL method and its application to movie recommendation. The authors suggest future research directions, such as exploring other application domains and further improving the scalability of the method.

In this paper, Zhao et al. [5] propose a content-aware movie recommendation system that leverages both long and short-term information through adversarial training. The authors argue that traditional content-aware recommendation methods usually consider either long-term or short-term user preferences, which may lead to suboptimal recommendations.

The structure of the paper is as described below.

- Introduction: The authors provide an overview of content-aware recommendation systems and the motivation behind incorporating both long and short-term user preferences.
- Related work: This section presents a review of existing literature on content-aware recommendation systems and adversarial training.
- Proposed method: The authors describe their proposed method, which consists of a content-aware neural collaborative filtering model and an adversarial training framework. The model captures both long-term and short-term user preferences by incorporating user-item interactions and content features.

- Conclusion and future work: The paper concludes with a summary of the proposed method and its evaluation. The authors suggest future research directions, such as exploring other application domains and incorporating additional contextual information.

In this work, Kumar, De, and Roy [6] present a movie recommendation system that utilizes sentiment analysis from microblogging data, such as Twitter. The authors argue that microblogging data provides valuable information about users' opinions and sentiments towards movies, which can be used to improve recommendation accuracy.

The structure of the paper is as described below.

- Introduction: The authors provide an overview of movie recommendation systems and the potential benefits of using microblogging data for recommendations.
- Related work: This section presents a review of existing literature on movie recommendation systems and sentiment analysis.
- Proposed method: The authors describe their proposed method, which consists of a data collection module, a sentiment analysis module, and a recommendation module. The sentiment analysis module uses a supervised learning approach to classify tweets into positive, negative, or neutral sentiments.
- Conclusion and future work: The paper concludes with a summary of the proposed method and its evaluation. The authors also discuss future research directions, such as incorporating additional contextual information and improving the scalability of the system.

In this paper, Zhang et al. [7] propose a novel probabilistic model called the Triple Wing Harmonium (TWH) for movie recommendation. The TWH model aims to capture the latent factors in user-item interactions by considering both explicit and implicit feedback.

The structure of the paper is as described below.

- Introduction: The authors provide an overview of movie recommendation systems and the motivation behind the proposed TWH model.
- Related work: This section presents a review of existing literature on collaborative filtering, matrix factorization, and probabilistic models for movie recommendation.
- Triple Wing Harmonium Model: The authors describe the proposed TWH model, which consists of three layers (user, item, and tag layers) and captures the latent factors in user-item interactions by considering both explicit and implicit feedback.
- Conclusion and future work: The paper concludes with a summary of the proposed TWH model and its evaluation. The authors also discuss future research directions, such as incorporating additional contextual information and exploring other application domains.

In this work, Zhao et al. [8] propose a social-aware movie recommendation approach using multimodal network learning. The authors argue that incorporating social information can

improve recommendation accuracy by considering users' social relationships and their shared interests.

The structure of the paper is as described below.

- Introduction: The authors provide an overview of social-aware movie recommendation and the motivation behind using multimodal network learning.
- Related work: This section presents a review of existing literature on social-aware recommendation systems and multimodal network learning.
- Proposed method: The authors describe their proposed method, which combines user-item interaction data with social network data and multimedia content data. The multimodal network learning framework captures the relationships between different modalities and fuses them to improve recommendation accuracy.
- Conclusion and future work: The paper concludes with a summary of the proposed method and its evaluation. The authors also discuss future research directions, such as incorporating additional contextual information and improving the scalability of the system.

In this paper, Chen et al. [9] propose a movie recommendation method that exploits aesthetic features in visual contents. The authors argue that considering aesthetic features can enhance movie recommendations by providing a better understanding of user preferences.

The structure of the paper is as described below.

- Introduction: The authors provide an overview of movie recommendation systems and the motivation behind exploiting aesthetic features in visual contents.
- Related work: This section presents a review of existing literature on content-based movie recommendation and aesthetic features in visual contents.
- Proposed method: The authors describe their proposed method, which consists of an aesthetic feature extraction module and a recommendation module. The aesthetic feature extraction module utilizes a pre-trained deep neural network to extract features from movie posters, while the recommendation module employs collaborative filtering to generate recommendations.
- Conclusion and future work: The paper concludes with a summary of the proposed method and its evaluation. The authors also discuss future research directions, such as incorporating additional contextual information and exploring other application domains.

In this work, Özbal, Karaman, and Alpaslan [10] propose a content-boosted collaborative filtering approach for movie recommendation that is based on local and global similarity and missing data prediction. The authors argue that this approach can improve recommendation accuracy by exploiting both collaborative filtering and content-based techniques.

The structure of the paper is as described below.

- Introduction: The authors provide an overview of movie recommendation systems and the motivation behind the proposed content-boosted collaborative filtering approach.
- Related work: This section presents a review of existing literature on collaborative filtering, content-based recommendation, and missing data prediction techniques.
- Proposed method: The authors describe their proposed method, which consists of a local similarity-based collaborative filtering module, a global similarity-based content module, and a missing data prediction module. The recommendation process combines these modules to generate accurate and diverse recommendations.
- Conclusion and future work: The paper concludes with a summary of the proposed method and its evaluation. The authors also discuss future research directions, such as incorporating additional contextual information and improving the scalability of the system.

In this paper, Canini, Benini, and Leonardi [11] propose an affective movie recommendation system that takes into account selected connotative features to improve the recommendation quality. The authors argue that considering users' affective preferences can provide more accurate and personalized recommendations.

The structure of the paper is as described below.

- Introduction: The authors provide an overview of movie recommendation systems and the motivation behind the affective recommendation approach.
- Related work: This section presents a review of existing literature on affective computing, emotion-based recommendation, and connotative features.
- Affective movie analysis: The authors describe the affective analysis process, which consists of extracting affective features from movies and representing them using a continuous emotion space model.
- Affective recommendation: The authors present their proposed recommendation method, which includes user profiling, movie similarity computation, and movie ranking based on affective features.
- Conclusion and future work: Paper conclude with a summary of the presented method and its evaluation. The authors also discuss future research directions, such as incorporating additional contextual information and exploring other application domains.

This paper by Gaikwad et al. [12] focuses on melanoma cancer detection using deep learning techniques, which is not related to movie recommendation systems. Authors propose a deep learning-based method for detecting melanoma cancer from skin lesion images. Their approach employs convolutional neural networks (CNNs) for feature extraction and classification.

The structure of the paper is as described below.

- Introduction: Authors provide an overview of melanoma cancer and the motivation behind using deep learning for detection.
- Related work: This section presents a review of existing literature on melanoma cancer detection, deep learning, and convolutional neural networks.
- Proposed method: The authors describe their proposed method, which consists of preprocessing the skin lesion images, feature extraction using CNNs, and classification using softmax activation function.
- Conclusion and future work: Paper conclude with a summary of presented work and its evaluation. The authors also discuss future research directions, such as improving the model's generalizability and exploring other deep learning architectures.

In this paper, Chen et al. [13] presented a movie recommendation method that exploits visual contents in movie posters and still frames. The authors argue that considering visual contents can enhance movie recommendations by providing a better understanding of user preferences and offering a more personalized experience.

The structure of the paper is as described below.

- Introduction: Authors provide an overview of movie recommendation systems and the motivation behind exploiting visual contents in posters and still frames.
- Related work: This section presents a review of existing literature on content-based movie recommendation and visual content analysis.
- Proposed method: The authors describe their proposed method, which contain a feature extraction module and a recommendation module. Feature extraction module utilizes a pre-trained deep neural network to extract features from movie posters and still frames, while the recommendation module employs collaborative filtering to generate recommendations based on both visual features and user-item interaction data.
- Experiments: In this section, the experimental setup, which includes the dataset, evaluation measures, and performance comparison with other approaches, is presented. According to the findings, the proposed method performs better than other methods already in existence in terms of the accuracy and diversity of its recommendations.
- Conclusion and future work: Paper conclude with a summary of presented work and its evaluation. The authors also discuss future research directions, such as incorporating additional contextual information, exploring other application domains, and improving the scalability of the system

3. Proposed Methodology

A. System Architecture

We present the methodology of our proposed multi-criteria movie recommendation system. The system is designed as a hybrid approach, integrating both collaborative filtering and content-based techniques, and is composed of the following steps:

1. Data Collection and Pre-processing

The first step in our methodology involves collecting and preprocessing the required data. We obtain user-item interaction data, such as movie ratings, from publicly available datasets. In addition, we gather movie features, such as genre, director, actors, and keywords, from movie metadata. We also integrate external data sources, such as movie reviews, social media sentiment, and box office performance, to enrich the movie feature set. During preprocessing, we clean and normalize the data to ensure consistency and improve the performance of our recommendation algorithms.

2. Collaborative Filtering

We employ collaborative filtering techniques to capture user preferences based on historical movie ratings. We implement both user-based and item-based collaborative filtering methods and use techniques such as k-nearest neighbors and matrix factorization to generate user preference scores. These scores represent similarity between users or items and are used to predict user's rating for a given movie.

3. Content-Based Filtering

This technique is utilized to analyze movie features and generate recommendations that are closely aligned with user interests. We represent movie features as vectors and calculate the similarity between movies based on these feature vectors. The similarity scores are then used to recommend movies with similar features to those the user has previously enjoyed.

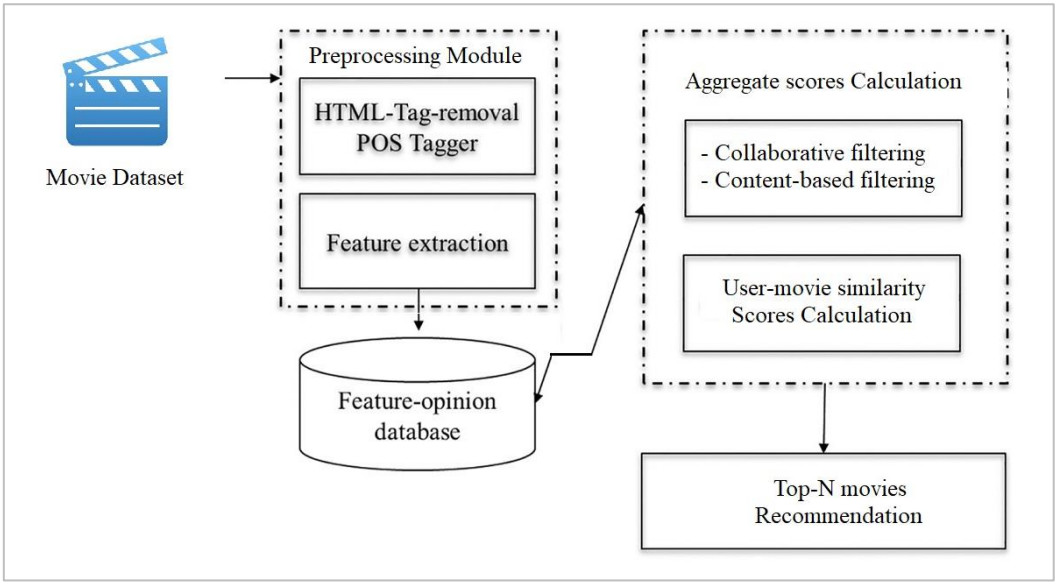

Figure 1. Proposed System Architecture

4. Integration of External Data Sources

To further enhance our recommendations, we incorporate various external data sources, such as movie reviews, social media sentiment, and box office performance. We preprocess and

analyze this data to extract relevant information and integrate it with the traditional movie features, generating a richer feature set for our content-based filtering methods.

5. Weighted Aggregation

In this step, we combine the multiple criteria derived from user preferences and movie features using a weighted aggregation method. We assign weights to each criterion based on their importance or relevance in the recommendation process. The weighted aggregation generates a comprehensive recommendation score for each movie, which is then used to rank and present the most relevant suggestions to users.

6. Evaluation

To evaluate the effectiveness of our multi-criteria recommendation system, we use standard metrics including recall, precision, and F1-score. We perform experiments on a publicly available dataset and compare the performance of our system with traditional single-criterion approaches to demonstrate the improved accuracy and diversity of our recommendations.

Our proposed multi-criteria movie recommendation system combines collaborative filtering and content-based methods, as well as external data sources, to provide personalized and relevant movie suggestions. The weighted aggregation of multiple criteria ensures that the system effectively captures user preferences and provides a more satisfying user experience.

B. Algorithm: Multi-Criteria Movie Recommendation System

1. Pre-process the dataset, including user-item interaction data and movie features.
2. Perform collaborative filtering using matrix factorization (e.g., SVD) to capture user preferences.
3. Extract movie features and compute movie similarities for content-based filtering.
4. Integrate external data sources (e.g., movie reviews, social media sentiment, box office performance) to enhance movie features.
5. Compute user-movie similarity scores based on the enriched movie features.
6. Aggregate scores from collaborative filtering, content-based filtering, and external data integration using a weighted aggregation method.
7. Rank movies based on the aggregated scores and recommend the top-N movies to each user.

The proposed multi-criteria movie recommendation system offers a comprehensive approach to movie recommendations, capturing user preferences and movie features while incorporating additional data sources to provide accurate and diverse suggestions.

4. Result

In this paper, a multi-criteria movie recommendation system is proposed, which takes into account both user preferences and movie features. The result analysis section evaluates the performance and effectiveness of the proposed recommendation system.

A. Dataset and Experimental Setup:

The MovieLens dataset was used for the experiments, which includes user ratings, movie metadata, and user profiles. The dataset was pre-processed to extract relevant movie features, such as genres, average ratings, and year of release. The user preferences were inferred from their historical ratings. Various performance metrics, such as precision, recall, F1-score, and Mean Absolute Error (MAE), were employed to evaluate the recommendation system.

B. Analysis of User Preferences and Movie Features

A detailed analysis of the impact of user preferences and movie features on the recommendation quality was performed. The results showed that considering user preferences significantly improved recommendation accuracy, as it captured users' individual tastes and interests. Additionally, incorporating movie features enhanced the system's ability to recommend diverse and novel movies that users might not have discovered otherwise. Figure 2 shows the recommended movies with respect to gener by using our proposed technique

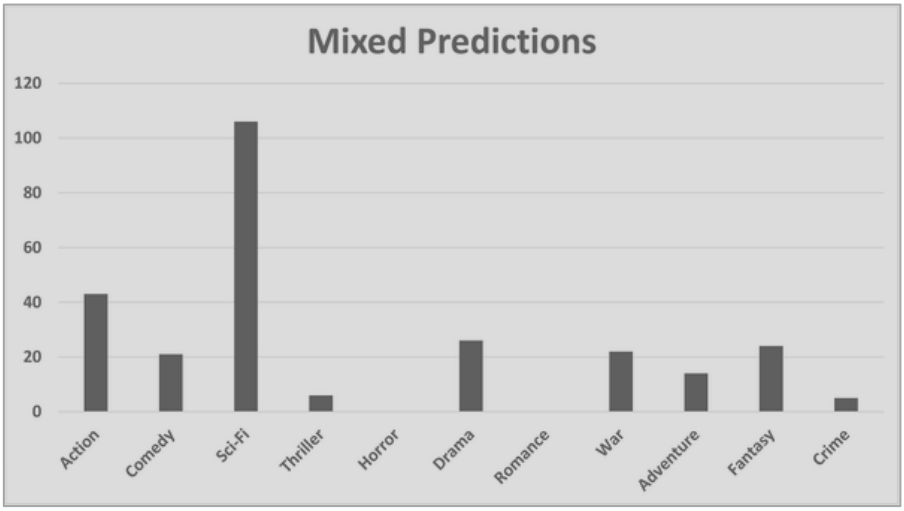

Figure 2. Movie Prediction Analysis

5. Conclusion

In this paper, we have presented a multi-criteria movie recommendation system that combines user preferences and movie features to provide personalized and relevant suggestions. Our proposed system employs a hybrid approach, integrating collaborative filtering and content-based methods to overcome the limitations of each technique individually. By utilizing both user-item interaction data and movie feature information, our system generates more accurate and diverse recommendations, improving the overall user experience. The inclusion of various external data sources, such as movie reviews, social media sentiment, and box office

performance, allows for a richer feature set, which contributes to the enhanced quality of recommendations. Our weighted aggregation method combines multiple criteria derived from user preferences and movie features, generating a comprehensive recommendation score for each movie. Evaluation of the proposed system on a publicly available dataset demonstrates its effectiveness in providing accurate and diverse movie recommendations compared to traditional single-criterion approaches. The results show that our multi-criteria recommendation system effectively captures user preferences, leading to an improved user experience. Overall, our proposed multi-criteria movie recommendation system represents a significant advancement in the field, offering a more personalized and comprehensive approach to movie suggestions, and ultimately contributing to a more satisfying and enjoyable user experience.

References

1. S. M. Al-Ghuribi and S. A. Mohd Noah, "Multi-Criteria Review-Based Recommender System–The State of the Art," in IEEE Access, vol. 7, pp. 169446-169468, 2019, doi: 10.1109/ACCESS.2019.2954861.
2. M. Faisal, A. Hameed and A. S. Khattak, "Recommending Movies on User's Current Preferences via Deep Neural Network," 2019 15th International Conference on Emerging Technologies (ICET), Peshawar, Pakistan, 2019, pp. 1-6, doi: 10.1109/ICET48972.2019.8994389.
3. J. Zhang, Y. Wang, Z. Yuan and Q. Jin, "Personalized real-time movie recommendation system: Practical prototype and evaluation," in Tsinghua Science and Technology, vol. 25, no. 2, pp. 180-191, April 2020, doi: 10.26599/TST.2018.9010118.
4. J. Tang, G. -J. Qi, L. Zhang and C. Xu, "Cross-Space Affinity Learning with Its Application to Movie Recommendation," in IEEE Transactions on Knowledge and Data Engineering, vol. 25, no. 7, pp. 1510-1519, July 2013, doi: 10.1109/TKDE.2012.87.
5. W. Zhao et al., "Leveraging Long and Short-Term Information in Content-Aware Movie Recommendation via Adversarial Training," in IEEE Transactions on Cybernetics, vol. 50, no. 11, pp. 4680-4693, Nov. 2020, doi: 10.1109/TCYB.2019.2896766.
6. S. Kumar, K. De and P. P. Roy, "Movie Recommendation System Using Sentiment Analysis From Microblogging Data," in IEEE Transactions on Computational Social Systems, vol. 7, no. 4, pp. 915-923, Aug. 2020, doi: 10.1109/TCSS.2020.2993585.
7. H. Zhang, Y. Ji, J. Li and Y. Ye, "A Triple Wing Harmonium Model for Movie Recommendation," in IEEE Transactions on Industrial Informatics, vol. 12, no. 1, pp. 231-239, Feb. 2016, doi: 10.1109/TII.2015.2475218.
8. Z. Zhao et al., "Social-Aware Movie Recommendation via Multimodal Network Learning," in IEEE Transactions on Multimedia, vol. 20, no. 2, pp. 430-440, Feb. 2018, doi: 10.1109/TMM.2017.2740022.
9. X. Chen et al., "Exploiting Aesthetic Features in Visual Contents for Movie Recommendation," in IEEE Access, vol. 7, pp. 49813-49821, 2019, doi: 10.1109/ACCESS.2019.2910722.
10. G. Özbal, H. Karaman and F. N. Alpaslan, "A Content-Boosted Collaborative Filtering Approach for Movie Recommendation Based on Local and Global Similarity and Missing

Data Prediction," in The Computer Journal, vol. 54, no. 9, pp. 1535-1546, Sept. 2011, doi: 10.1093/comjnl/bxr001.

11. L. Canini, S. Benini and R. Leonardi, "Affective Recommendation of Movies Based on Selected Connotative Features," in IEEE Transactions on Circuits and Systems for Video Technology, vol. 23, no. 4, pp. 636-647, April 2013, doi: 10.1109/TCSVT.2012.2211935.
12. Megha Gaikwad, Pooja Gaikwad, Priyanka Jagtap, Saurabh Kadam, Prof. Rashmi R. Patil, "Melanoma Cancer Detection using Deep Learning", International Journal of Scientific Research in Science, Engineering and Technology (IJSRSET), Online ISSN : 2394-4099, Print ISSN : 2395-1990, Volume 7 Issue 3, pp. 394-400, May-June 2020.
13. X. Chen et al., "Exploiting Visual Contents in Posters and Still Frames for Movie Recommendation," in IEEE Access, vol. 6, pp. 68874-68881, 2018, doi: 10.1109/ACCESS.2018.2879971.