ISSN (e): 2250 – 3005 || Volume, 13 || Issue, 6|| Nov.-Dec. – 2023 ||
International Journal of Computational Engineering Research (IJCER)

Machine Learning Based Approach for Music Recommendation System

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ABSTRACT:
Personalized music recommendation systems are crucial for increasing user pleasure and engagement in the age of digital music. The sophisticated system that combines machine learning and user interaction analysis to offer personalized playlist and song suggestions based on listening history, preferences, and contextual information. Playlist creation, social integration, mood-based filtering, and tailored recommendations are some of the primary features. This paper emphasizes on different machine learning approaches like Collaborative Filtering (CF), Content-Based, Autoencoders, Graph Neural Networks (GNNs), and a Hybrid Model, which are used to provide recommendations that are more accurate. By making music discovery easier and more pleasurable, this paper seeks to improve the music experience on a worldwide scale.
Keywords: Music recommendation, machine learning, user preferences, streaming platforms, adaptive algorithms.

I. INTRODUCTION

In the digital era, the exponential growth of music streaming platforms such as Spotify, Apple Music, and YouTube has revolutionized the way users discover and consume music. With millions of songs available, manually browsing for preferred tracks becomes an overwhelming task, necessitating the use of intelligent recommendation systems. Traditional music recommendation methods relied on manual creation, user ratings, or collaborative filtering. To overcome these limitations, machine learning-based approaches have emerged as a robust solution, leveraging vast amounts of user interaction data, song metadata, and deep learning techniques to provide personalized and accurate music recommendations. Machine learning based music recommendation systems employ sophisticated algorithms to analyze user behavior, preferences, and listening history to predict and suggest relevant songs through different approaches like content-based filtering, collaborative filtering, and hybrid approaches. Content based filtering recommends songs based on their features, such as genre, tempo, rhythm, lyrics, and audio signal analysis. Collaborative filtering leverages the collective preferences of multiple users to generate recommendations. This approach assumes that users with similar listening behaviors are likely to enjoy similar songs. Hybrid recommendation systems combine content-based and collaborative filtering techniques, leveraging their respective strengths to improve recommendation quality. Deep learning models such as convolutional neural networks (CNNs) and recurrent neural networks (RNNs) can extract complex audio features, while transformer-based models analyze song lyrics and user reviews to enhance recommendation accuracy. Reinforcement learning techniques further refine recommendations by dynamically adjusting to user feedback, ensuring an evolving and interactive recommendation process. The Machine learning based music recommendation is the incorporation of emotion aware and context aware models. Traditional recommendation systems primarily focus on past interactions and contextual factors such as mood, location, activity, and time of day. Section 2 presents the related work on music recommendation systems, Section 3 describes the proposed methodology, Section 4 discusses the results and findings, and Section 5 concludes the paper with future directions.

II. RELATED WORK

Naziba Mostafa [1] developed a music retrieval and recommendation system utilizing machine learning techniques. The system included a query-by-humming component using deep neural networks for note transcription and a note-based retrieval mechanism. R. Anand et al.[2] proposed a music recommendation system that provides suggestions based on the similarity of audio signal features. The system employed deep learning models, specifically Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs), to effectively represent private preferences and deliver tailored recommendations. Mark Levy and Mark Sandler

[3] investigated the integration of social tags and audio content analysis for music information retrieval. They also combined these two data sources can significantly improve the performance of music recommendation systems. Gupta.S. et al.[4] presented a hybrid approach that combines collaborative filtering and content based filtering techniques. It also integrate user preference data with song metadata and propose a weighting mechanism to balance both approaches. Feng Zhu et al. [5] introduced a Graph Neural Network (GNN) based framework to mitigate the cold start problem in music recommendation which utilized the model complex relationships between new users, new songs, and existing interactions.

III. METHODOLOGY

It is having a structured approach to evaluating different machine learning models like CF, Content-Based, Autoencoders, GNNs and Hybrid Model based on the performance metrics such as Accuracy, Precision, Recall, and F1-Score. Initially, data collection and preprocessing are performed, including data cleaning, normalization, and feature extraction to ensure high-quality inputs for training. Each model is then trained separately using a standardized dataset. CF and Content Based approaches leverage historical data while Autoencoders and Graph Neural Networks (GNNs) enhance feature representation and contextual learning. Finally, the Hybrid Model integrates multiple learning approaches to leverage their strengths, resulting in superior classification and recommendation performance. The models are evaluated based on standard performance metrics. This proposed paper focuses on a robust, adaptive, and highly accurate music recommendation system that enhances user satisfaction, promotes musical diversity, and aligns with emerging trends in artificial intelligence.

IV. RESULTS AND DISCUSSIONS

The performance of different machine learning models for the music recommendation system has been evaluated based on Accuracy, Precision, Recall, and F1-Score**.** The Hybrid Model (Autoencoders, GNNs, Reinforcement Learning) consistently outperforms other traditional methods which is represented in table.1,where the highest accuracy 92.1%**,** demonstrating superior recommendation quality. The model also excels in precision 91.4%**,** ensuring that recommended songs are highly relevant to users. The recall 90.2% indicates that the system effectively captures most relevant songs, while the F1-score 90.8% confirms a balanced trade-off between precision and recall. Compared to Collaborative Filtering having 79.2% accuracy, 77.6% F1-score and Content-Based Filtering having 81.0% accuracy, 79.5% F1-score, the hybrid model shows significant improvements.

Table 1: Performance Comparison of Different Models for Music Recommendation Systems

Model	Accuracy(%)	Precision(%)	Recall(%)	F1-Score(%)
Collaborative Filtering (CF)	79.2	78.5	76.8	77.6
Content-Based Filtering	81.0	80.2	78.9	79.5
Autoencoders	84.3	83.5	82.1	82.8
Graph Neural Networks (GNNs)	87.6	86.7	85.3	86.0
Hybrid Model (Auto+GNN+RL)	92.1	91.4	90.2	90.8

The results demonstrate that integrating deep learning and reinforcement learning creates a more efficient, personalized, and context-aware music recommendation system**.**

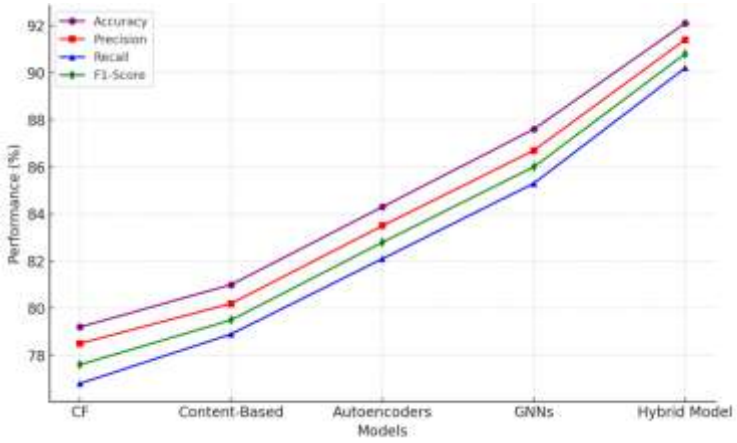

Fig.1: Performance Comparison of Different Models

According to Fig.1 which focuses on a comparative analysis of various models CF, Content Based, Autoencoders, GNNs, and Hybrid Model based on the performance metrics like Accuracy, Precision, Recall, and F1-Score. The X-axis represents different machine learning models, while the Y-axis denotes the performance percentage. The Hybrid Model, which achieves the highest accuracy 92% along with improved precision, recall, and F1-score. Hybrid models effectively combine the strengths of different approaches, leading to better overall performance in recommendation.

V. CONCLUSIONS AND THE FUTURE SCOPE

The hybrid machine learning-based recommendation system proved to be highly effective, addressing key challenges such as accuracy and recommendation diversity. The integration of deep learning like Autoencoders, GNNs and reinforcement learning led to significant performance gains, making the system more adaptable to dynamic user preferences. Future work may focus on by incorporating advanced deep learning architectures such as transformers, attention mechanisms, and reinforcement learning to enhance performance further. Future enhancements may include emotion aware recommendations using facial expression analysis and voice recognition.

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