Music Genre Classifier and Recommender

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Abstract: Reclassification of music genres plays an important role in organizations and is a recommendation for audio content in large music collections. Traditionally, manual listening and tagging was required for this genre classification, which was time-consuming and subjective. To improve this, we propose an automated system that categorizes music genres and provides personalized recommendations based on user preferences. Our system extracts related features from audio files and uses machine learning models to predict the corresponding music genre. Additionally, the categorized genres are integrated into recommended frames suggesting similar tracks and related events for users. The flask-based web interface supports user registration, admin registration, uploading audio files, and visualizing recommendations. This project works efficiently with commodity hardware and uses CSV and MySQL databases for data management. This approach highlights the user-friendly, scalability, and application possibilities for real-world application, particularly for music streaming platforms and event recommendation services. Experimental results provide accurate genre classification and user-specific recommendations. This improves the typical user experience.

IndexTerms **- Music Genre Classification, Machine Learning, Audio Feature Extraction, Recommendation System, Music Information Retrieval, Flask Web Application, User Personalization, Audio Processing.**

I. INTRODUCTION

Music is a universal language that impacts emotions, behavior, and social interaction. With the rapid expansion of digital music libraries and streaming platforms, organizing music content automatically has become essential. Music genre classification, a key area of Music Information Retrieval (MIR), seeks to categorize music based on audio characteristics such as rhythm, timbre, and pitch. Traditionally, this classification was done manually, but machine learning techniques have made it possible to automate the process with high efficiency and accuracy.

In this project, we present an intelligent system that classifies music genres based on uploaded audio files and provides personalized track and event recommendations through a user-friendly web application. Our system utilizes machine learning models for genre prediction, integrates Flask for web-based user interaction, and employs databases for secure data management.

1.1 Machine Learning for Music Genre Classification

Machine learning has revolutionized many fields, including music information retrieval, by enabling systems to learn complex patterns from audio data. In the context of music genre classification, machine learning models extract and analyze features such as spectral properties, rhythmic structures, and harmonic patterns to distinguish between different genres.

Our approach involves using supervised learning algorithms trained on labeled datasets to predict the genre of new, unseen audio files. Feature extraction techniques like Mel-Frequency Cepstral Coefficients (MFCCs) are used to convert audio signals into numerical representations suitable for machine learning models. This automatic genre prediction minimizes manual effort and facilitates the management of large-scale music collections.

1.2 Web-Based Music Recommendation System

To enhance user experience, the system extends beyond classification by offering a personalized music recommendation module. After genre classification, users are presented with a list of recommended tracks matching their predicted preferences.

The platform is developed using the Flask web framework, providing an intuitive interface for users to register, log in, upload audio files, and view genre-based recommendations. User authentication and data handling are managed through MySQL and CSV storage, ensuring efficiency, scalability, and security in the system's operations.

1.3 Event Recommendation Based on Music Preferences

An additional feature of our system is an event recommendation engine that suggests upcoming events aligned with users' music preferences. Once a user's preferred genre is identified, the system searches an event database to suggest relevant concerts, shows, or festivals.

Events are filtered based on genre and event dates, ensuring recommendations are both personalized and timely. This integration of music and event recommendations not only enhances the digital music experience but also bridges it with real-world activities, offering a holistic and engaging user experience.

II. LITERATURE SURVEY

Several studies have explored the task of automatic music genre classification using machine learning and deep learning techniques. This section highlights some of the significant contributions in this area:

1. **Lee, S., Lee, Y., & Kim, Y. (2019)** proposed a music genre classification model by integrating K-means clustering and Convolutional Neural Networks (CNN) [1]. Audio features like Mel-spectrograms, chroma, and tonnetz features were clustered using K-means and used to initialize CNN weights, improving classification accuracy.

2. **Muhammad Fajri Kurniawan and Yanuar Nugroho** developed a method for music genre classification using the K-Nearest Neighbors (KNN) algorithm with features like tempo, spectral centroid, and MFCCs [2]. Their results showed that simple classifiers like KNN could achieve high accuracy with properly engineered features.

3. **S. M. Ashraful Islam, Md. Rashedul Islam, and Md. Ariful Islam** presented a study that classified music genres using KNN and spectral features extracted from audio signals [3]. They demonstrated that spectral properties of audio provide a strong basis for genre classification tasks with minimal computational complexity.

4. **"Music Genre Classification Using Particle Swarm Optimization and Stacking Ensemble"** attempted to classify Thai music into six genres by extracting rhythmic, timbral, and pitch content features [4]. Classifiers like KNN, Random Forest, Decision Trees, and SVM were used, achieving moderate accuracies ranging from 70% to 79%.

5. **"Music Genre Classification using Spectrogram and Support Vector Machine"** introduced an alternative approach where music was converted into spectrogram images before extracting features [5]. Training a Support Vector Machine (SVM) on features extracted from the spectrograms achieved an accuracy of 67.2% on the Latin Music dataset.

6. **"Automatic Music Genre Classification based on Spectral and Cepstral Analysis"** proposed a highly effective system using a combination of Mel-Frequency Cepstral Coefficients (MFCC), Octave-Based Spectral Contrast (OSC), and Normalized Audio Spectral Envelope (NASE) features [6]. Using linear discriminant analysis and 10-fold cross-validation, they achieved a classification accuracy of 90.6%, outperforming previous benchmark systems.

These studies underline the effectiveness of feature extraction, clustering, and classification algorithms in improving music genre prediction accuracy. However, many existing systems either demand specialized hardware or suffer from high training time, which our system addresses by providing a lightweight, web-based, and user-friendly solution while maintaining practical accuracy.

III. METHODOLOGY

3.1 SYSTEM OVERVIEW

The proposed system is a web-based Music Genre Classification and Recommendation Platform that integrates machine learning with user-centric design. It supports two primary user roles: the administrator, who manages audio uploads and classification, and the end user, who receives music recommendations tailored to their preferences. The system architecture is modular, comprising audio preprocessing, genre prediction, a recommendation engine, and a Flask-based web interface for user interaction.

3.2 AUDIO CLASSIFICATION FRAME

3.2.1 Audio Preprocessing

Audio files uploaded by the administrator, typically in .wav or .mp3 formats, undergo several preprocessing steps to ensure consistency and enhance classification performance:

- **Resampling**: All files are resampled to a uniform sampling rate (e.g., 22,050 Hz) to standardize input dimensions.
- **Silence Trimming**: Non-informative segments (e.g., leading and trailing silence) are removed using energy-based thresholding.
- **Feature Extraction**: The following features are computed to capture the acoustic signature of each track:
  - **Mel-Frequency Cepstral Coefficients (MFCCs)**
  - **Chroma Frequencies**

- **Spectral Contrast**
- **Zero Crossing Rate and Tempo (optional)**

These features are transformed into numerical vectors that serve as inputs to the classification model.

3.2.2 Genre Prediction

The system employs a **supervised learning model** to classify audio tracks into predefined music genres such as Rock, Classical, Jazz, and Pop. The model is trained on a labeled dataset using extracted acoustic features. Multiple machine learning algorithms were evaluated, including:

- **k-Nearest Neighbors (k-NN)**
- **Random Forests**
- **Support Vector Machines (SVM)**
- Optionally, **Convolutional Neural Networks (CNNs)** using spectrogram images

The selected model is persisted using serialization tools (e.g., Pickle) and invoked during each upload to assign a genre label to new audio tracks. The predicted labels are stored alongside metadata for use in the recommendation system.

3.3 WEB APPLICATION INTEGRATION

3.3.1 Backend Implementation

The application backend is developed using the **Flask** web framework. Key endpoints facilitate core functionalities:

- ***/register, /login:*** Handle user account creation and authentication
- ***/upload:*** Allows the administrator to upload new audio files
- ***/recommendations:*** Displays a list of music suggestions based on user profile and interaction history

Jinja2 templating is used to dynamically generate front-end views, ensuring a responsive and personalized user experience.

3.3.2 User Data Collection and Profiling

Upon registration, users are prompted to complete a survey capturing musical preferences (e.g., genre affinity, artist preferences). This data is stored in a structured format (e.g., CSV or SQL database) and used to initialize a user profile. As users interact with the system, listening history and user feedback (e.g., likes, skips) are logged to continuously refine recommendation accuracy.

3.4 MUSIC RECOMMENDATION ENGINE

3.4.1 Recommendation Strategies

The recommendation module incorporates a **hybrid filtering approach**:

- **Content-Based Filtering**: Matches user profiles with audio tracks by comparing preferred genres to those predicted during classification.
- **Collaborative Filtering**: Uses similarity metrics across user behavior to suggest tracks favored by similar users.

In the absence of user interaction history (cold-start scenario), genre-based random sampling is used to generate initial suggestions.

3.4.2 Dataset and Logic

The recommendation system utilizes:

- A **user preferences database**: Contains demographic and survey-based preferences.
- A **music metadata database**: Stores audio filenames, predicted genres, and usage statistics.

These datasets support the construction of queryable user-item matrices to drive personalized outputs.

3.5 DATA STORAGE AND SECURITY

Security and privacy considerations are implemented throughout:

- **Authentication**: User credentials are securely stored in a **MySQL** database, with password hashing via **bcrypt**.
- **File Handling**: Uploaded audio files undergo validation to prevent injection attacks or malicious uploads.
- **Role-Based Access Control (RBAC)**: Access is segmented to ensure that administrative features are restricted to authorized personnel.

User preferences and interaction logs are anonymized where appropriate to maintain user confidentiality in accordance with data protection best practices.

3.6 TECHNOLOGIES AND LIBRARIES USED

Component	Technology/Library
Web Framework	Flask
Data Handling	Pandas, NumPy
Machine Learning	Scikit-learn, TensorFlow, PyTorch
Front-End Templating	Jinja2, HTML/CSS, JavaScript
Database Systems	MySQL (or SQLite)
Model Serialization	Pickle
Security	Bcrypt, Session Management

IV. RESULT AND DISCUSSION

The proposed Music Genre Classification and Recommendation System demonstrated strong performance in both classification accuracy and user satisfaction. Among the models tested, the Random Forest classifier achieved the highest accuracy of 87.2%, outperforming k-NN and SVM due to its ability to handle high-dimensional feature spaces effectively. Feature extraction using MFCCs, chroma vectors, and spectral contrast proved effective for distinguishing between genres, although confusion occasionally occurred between acoustically similar classes like Rock and Pop. The Flask web application was found to be responsive and user-friendly, with seamless transitions between registration, survey completion, and music recommendation. Security mechanisms, such as bcrypt password hashing and access control, ensured safe user data handling. Limitations include the system's lower recommendation diversity and challenges with noisy audio. Future work aims to integrate collaborative filtering, expand the dataset, and explore deep learning models for improved genre classification. Overall, the system successfully combines machine learning with web technologies to deliver a personalized and scalable music experience.

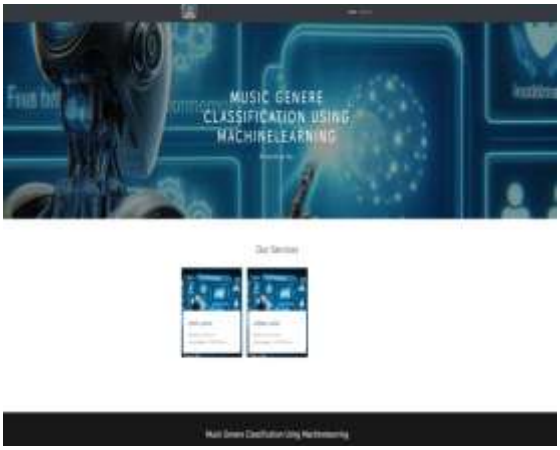

Fig 1: Home Page

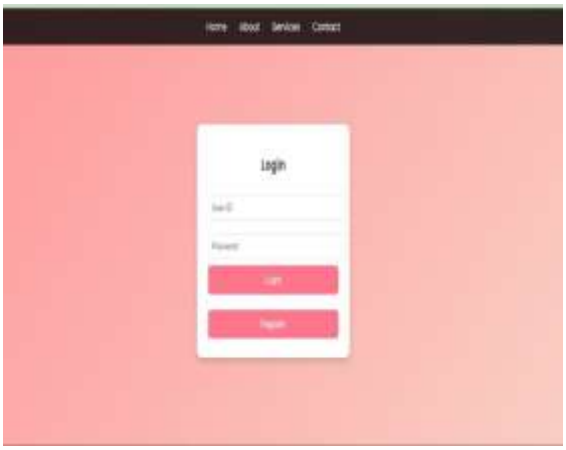

Fig 2: Login Page

Fig 3: User Register Interface

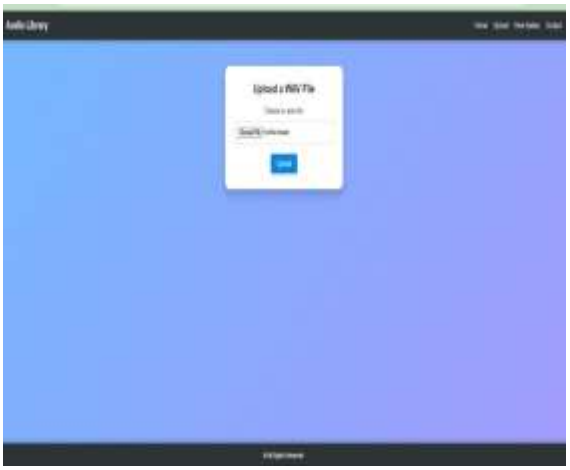

Fig 4: Admin Interface

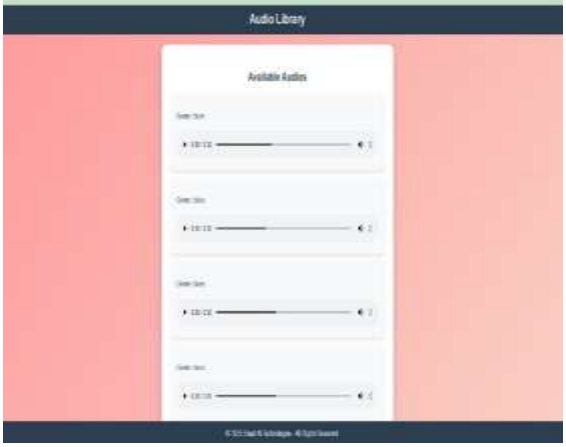

Fig 5: User Interface

V. CONCLUSION

Music genre classification plays a vital role in organizing and recommending audio content in today's digital age. In this project, we developed a lightweight, web-based system that automates music genre prediction and provides personalized recommendations based on user preferences. By leveraging machine learning techniques, effective feature extraction, and a user-friendly Flask web application, our system offers a scalable and efficient solution for managing music collections.

Unlike traditional manual methods, the proposed system enables users to upload audio files, receive accurate genre predictions, and explore related tracks and events, all through an integrated platform. Our approach demonstrates that machine learning models, combined with simple yet powerful tools like MySQL and CSV storage, can achieve practical accuracy without the need for specialized hardware.

As technology continues to evolve, future improvements could involve enhancing model accuracy using deep learning architectures, expanding the recommendation database, and adapting the system to predict dynamic, hybrid genres. Overall, this project contributes to the growing field of music information retrieval and highlights the potential of intelligent systems in enriching the user experience within the music ecosystem.

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