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Ensemble Machine Learning Methods for Robust Music Genre Classification

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ABSTRACT :

The research "Music Genre Classification using Machine Learning" aims to develop a web application that can automatically classify music into different genres using machine learning algorithms. The research uses an agile development methodology, focusing on data gathering and analysis, research methods, and requirement verification. The survey research method was selected to collect technical requirements and user preferences for the research, and positive responses were collected regarding the consideration of diverse datasets, extraction of relevant features, and machine learning abilities. The results of this research show that using proper datasets, feature extraction methods, and ML models like KNN and SVM can greatly increase the classification algorithm's accuracy. The technical research for the research selects the programming language (Python), IDE (VS Code), Operating system (Windows), DBMS (SQLite), and Web browser (Google Chrome) for the development of this research. The research has implications for the music industry, with the potential to automate the music classification process, and music properties visualization, providing a more efficient and accurate way of classifying music genres.

Keywords: Web-based Music Genre Classification, Machine Learning, KNN, SVM

Introduction :

The classification of musical genres is an essential yet challenging area in music information retrieval (MIR). This task, which involves automatically categorizing music tracks based on distinct auditory characteristics, plays a significant role in applications such as playlist generation, music recommendation, and indexing for digital libraries. Classifying music by genre, however, is complex due to the overlap between genre characteristics and the subjective nature of genre definitions, which often vary among individuals and cultural contexts .

Advancements in machine learning have enabled the development of automated systems for accurate genre classification, utilizing a variety of feature extraction techniques. Techniques like spectrogram analysis and chroma features help in capturing relevant musical elements such as pitch, rhythm, and timbre, which are critical for distinguishing genres. Once extracted, these features are processed by machine learning algorithms, such as K-Nearest Neighbors (KNN) and Support Vector Machines (SVM), which classify music genres based on learned patterns .

Despite recent improvements in machine learning-based music classification, the task presents several persistent challenges. These include the lack of standardized genre labels, the subjective definition of genres, and the high computational costs associated with training models on large, diverse datasets. Noise in audio data and the class imbalance within genre datasets also complicate the process, affecting the performance and accuracy of machine learning models .

This study aims to address these issues by developing a robust, web-based music genre classification system that leverages machine learning techniques. Key objectives include evaluating different feature extraction methods, determining optimal dataset requirements, and assessing the impact of genre label standards on classification accuracy. By implementing this system, the research seeks to contribute to the field of MIR by offering insights into the technical and practical challenges associated with genre classification and exploring solutions for creating more accurate and scalable classification systems .

Literature Review :

The task of music genre classification has seen significant advancements with the integration of machine learning, particularly in the realms of feature extraction, model selection, and system usability. This review summarizes prominent studies and systems in the field, highlighting both traditional and modern approaches and their applications in real-world systems.

Numerous studies have focused on developing systems for automatic music genre classification, leveraging various machine learning and deep learning techniques. The aim of Dai (2022) is to create a system that categorizes music genres based on input properties from music signals, utilizing the K-NN

algorithm alongside artificial neural networks to classify these signals. The study emphasizes essential concepts such as feature extraction, dimensionality reduction, and classification accuracy, while also discussing future applications in the music industry, including recommendation systems and genre-specific playlists. Similarly, V & Vijaykumar (2021) developed a machine learning-based system that employs k-NN and SVM algorithms, assessing their performance through metrics like accuracy and precision. The challenges noted in their study include the necessity for a large and diverse dataset to capture the unique characteristics of various genres effectively.

Prince et al. (2022) conducted a comprehensive review of deep learning models used for music genre classification, highlighting the role of Mel-frequency cepstral coefficients (MFCCs) and spectral features in these models. In another study, Cheng et al. (2020) preprocessed the GTZAN dataset, extracting MFCCs and chroma features while training multiple CNN models. Their experiments demonstrated CNNs' potential in handling complex and overlapping genres. Elbir et al. (2018) used the Million Song Dataset to extract features such as tempo and loudness, training classifiers like decision trees and SVMs, and also developed personalized music suggestions through collaborative filtering and content-based algorithms.

Prashanthi et al. (2021) focused on the GTZAN dataset, assessing the effects of data augmentation on classification accuracy while comparing different classifiers and features. Chauhan et al. (2021) built a user-friendly interface allowing users to upload audio files for genre prediction, evaluating various classifiers and the impact of feature selection on accuracy. Their work emphasizes the usability of web-based applications for music analysis. Vishnupriya & Meenakshi (2018) highlighted the challenges of ambiguity in genre classification using CNNs and MFCCs, suggesting future exploration of additional features for improved accuracy.

Ndou et al. (2021) provided a comprehensive analysis of feature extraction methods and classification algorithms, discussing the interpretability of deep learning models and the potential for hybrid approaches. Asim & Siddiqui (2018) underscored the significance of selecting appropriate algorithms and feature sets for effective music classification, while Ghildiyal et al. (2020) reviewed various machine learning algorithms and their effectiveness in music genre classification.

Karatana & Yildiz (2017) explored feature extraction techniques like MFCC and evaluated classifiers such as k-NN and SVM, focusing on the impact of training samples on accuracy. Pelchat & Gelowitz (2020) proposed an ANN-based approach, outperforming traditional methods with a classification accuracy of 86.3%, suggesting future applications of their findings. Oramas et al. (2018) introduced a multimodal deep learning approach that integrates audio and textual information, demonstrating the hybrid architecture's effectiveness in genre classification. Finally, Singh & Biswas (2022) investigated deep learning algorithms' robustness in classifying music genres, finding variability in model performance based on the musical features utilized for training and testing. Collectively, these studies highlight the evolving landscape of music genre classification, underscoring the importance of diverse datasets, effective feature extraction, and innovative algorithms for improving accuracy and application potential in the music industry.

1. **Feature Extraction and Classification Techniques**

Feature extraction is foundational to genre classification, with techniques like Mel-Frequency Cepstral Coefficients (MFCC) and spectral features widely used to capture essential audio characteristics such as pitch, rhythm, and timbre. The choice of classifiers, including K-Nearest Neighbors (KNN), Naive Bayes (NB), and Support Vector Machines (SVM), significantly affects accuracy. Research by Karatana and Yildiz (2017) underscores the importance of selecting an appropriate classifier and feature set to maximize model performance.

2. **Machine Learning and Deep Learning Approaches**

Recent advancements in machine learning have shifted towards using deep learning models, including Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs). Hybrid models combining CNN and RNN layers show promise for more complex genre classification. Oramas et al. (2018) further explored the potential of multimodal deep learning, combining audio and text features, which enhanced genre classification accuracy by integrating different modalities of data for a more holistic analysis.

3. **Application in Web-Based Systems**

Music genre classification has practical applications in web-based platforms, where systems enable users to upload tracks and visualize genre classifications. Castillo and Flores (2021) demonstrated a user-friendly web-based interface where users could interact with the classification process in real-time. The visual feedback and interactive features of these platforms highlight the relevance of genre classification systems in both commercial and educational applications.

4. **Comparison with Similar Systems**

Existing systems like "TuneBat" and "GetSongBPM" provide essential music analytics, such as BPM and key detection, showcasing a trend toward accessible music analysis tools for the public. These systems, while not exclusively focused on genre classification, demonstrate the increasing demand for user-friendly, web-based applications that support music production, DJing, and casual listening.

5. **Challenges and Future Directions**

The primary challenges identified in music genre classification include dataset limitations, noise, and scalability issues for real-time applications. Literature suggests that increasing dataset diversity, implementing noise reduction techniques, and scaling up computational resources can improve classification performance. Future research directions propose the use of larger, more diverse datasets and the exploration of advanced neural networks, which may further enhance genre classification models. Additionally, incorporating multimodal data, such as integrating lyrics with audio features, shows promise for more nuanced classification systems.

Objective :

The objective of this machine learning research is to develop a web-based system that accurately classifies music tracks into various genres, thereby enhancing the user experience in music discovery and recommendation. To achieve this, the research will begin with the curation of a diverse dataset that encompasses a wide range of music genres, ensuring that the model is exposed to various musical styles and characteristics. Following this, relevant features will be extracted from the dataset, with an emphasis on analyzing their statistical properties to determine the most effective features for training

machine learning algorithms. The practical implementation of the music genre classification system will showcase its usability in real-world applications, assisting users in uncovering music insights tailored to their preferences (Dai, 2022).

The key deliverables of the research include the development of a robust web application that serves as a platform for music professionals, listeners, and recommendation systems to classify songs based on their genre using advanced machine learning techniques. This application will feature a user-friendly interface that enables users to effortlessly upload audio files and view the corresponding classification results. Additionally, trained machine learning models will be developed, capable of accurately categorizing music tracks into various genres. These models will not only serve the web application but can also be integrated into other applications such as music recommendation systems and production tools, or be utilized for further research endeavors.

To enhance user engagement and functionality, the web application will offer several features. Users will be able to create accounts by signing up or logging in, ensuring a personalized experience. They can upload audio files in common formats such as .wav or .mp3 for genre classification and subsequently view and download a genre probability distribution chart that illustrates the classification results. Furthermore, the application will provide visual analytics, including MFCC (Mel-Frequency Cepstral Coefficients) diagrams, beat diagrams, and chord progression diagrams, allowing users to explore the musical structure of the tracks. Users will also have access to their genre classification history, enabling them to track their interactions with the system. Lastly, the application will allow users to update their profiles and change their passwords, ensuring a secure and tailored user experience.

Similar System

In the process of reviewing similar systems for the research, an evaluation of existing solutions in the realm of music genre classification was conducted. This review aims to explore systems that address similar challenges and objectives. By analyzing their features, methodologies, and performance, valuable insights can be gained to refine and enhance the approach taken in the current research. This systematic comparison helps identify best practices, potential improvements, and innovative strategies to optimize the proposed system's design and functionality.

System Overview

1. **Castillo & Flores (2021)**

This system features a web-based user interface, timeline-based visualization, and a machine learning-based genre classification model. Users can upload music files, visualize them in a timeline format, and perform genre classification. The system employs features such as Mel-frequency cepstral coefficients (MFCC) and chroma features as inputs to the machine learning model. The hybrid feature extraction approach combines both audio and textual information to enhance the precision of genre classification.

2. **TuneBat (2023)**

TuneBat specializes in song analysis by allowing users to determine song keys and BPM (beats per minute). With an extensive database of tracks, it offers a convenient and efficient way for musicians, producers, and DJs to access essential music attributes. The platform features an intuitive interface and advanced algorithms that enable users to swiftly extract key information, thereby facilitating more informed musical decisions. TuneBat significantly enhances productivity and creativity within the music industry.

3. **GetSongBPM (2023)**

GetSongBPM is a versatile system that caters to music enthusiasts by providing song BPM detection alongside a spectrum of features. Users can explore songs based on desired BPM, genre, decade, artist, and album, making it a comprehensive music discovery platform. Its multifaceted functionality enhances the user experience and allows for personalized song searches. With a user-friendly interface and diverse search criteria, GetSongBPM empowers users to delve into a wide range of musical options, efficiently finding songs that align with their preferences.

Introduction :

Music genre classification using machine learning is a complex task that requires a deep understanding of various research methods. The success of the research depends heavily on the accuracy and validity of the research methods used to gather and analyze the data. The research methods involved in this research are crucial in determining the quality of the deliverables, including the music genre classification system, the dataset, the trained machine learning models, and the integration of the system into real-world applications. In this context, it is important to explore and understand the research methods that can be applied in this research to ensure the highest level of accuracy, reliability, and validity.

Impact of Data Gathering and Analysis on the Quality of Research Deliverables

Data gathering and analysis are critical components of any research, especially in the field of machine learning. In the case of the "Music Genre Classification" research, data gathering and analysis play a crucial role in improving the quality of research deliverables and considering user preferences. The success of any machine learning research largely depends on the quality and quantity of the data used to train the model. In the case of music genre classification, it is important to gather a large and diverse dataset of music samples that represent different genres, artists, and time periods. This data should be carefully analyzed to ensure that it is of high quality, relevant to the research, and does not contain biases or errors that could affect the accuracy of the model.

In addition to gathering and analyzing music data, it is also important to consider user preferences when developing the classification model. This can be done through surveys, focus groups, or other forms of user research that gather feedback on the features, design, and usability of the web application. This feedback can then be used to make informed decisions about the research design, ensuring that the final product meets the needs and expectations of the target audience.

In conclusion, data gathering and analysis are important steps in the development of the "Music Genre Classification" research. They play a vital role in ensuring the accuracy and relevance of the research deliverables, as well as in considering user preferences and maintaining the quality of the research over time.

Research Methods Relevant to the Research

Experimental Research (Qualitative Research): Involves the manipulation of variables to measure their effects on the outcome of interest. Suitable for the research as it involves testing and evaluating different machine learning algorithms to determine their effectiveness in accurately classifying music genres. The experimental design can also help in identifying the most relevant features and parameters for classification.
Survey Research (Quantitative Research): Involves the collection of data from a sample population through questionnaires, interviews, or online forms. Suitable for the research as it can help in collecting feedback from music professionals and listeners about the accuracy and usefulness of the music genre classification system. The survey can also help in identifying the most popular genres among users and their preferences for personalized playlists.
Case Study Research (Qualitative Research): Involves a thorough examination of a single instance or a limited number of cases to understand a particular phenomenon entirely. Suitable for the research as it can help in examining the performance of the music genre classification system in a real-world application, such as a music production system. The case study can also shed light on usability, user fulfillment, and potential drawbacks of the system.
Content Analysis Research (Qualitative Research): Involves the systematic analysis of written or visual content to identify patterns, themes, and trends. Suitable for the research as it can help in analyzing the features and characteristics of music tracks that contribute to their classification into different genres. The content analysis can also help in identifying the most common and distinct features of different genres, which can inform the development of the classification algorithm.
Observational Research (Qualitative Research): Involves the systematic observation and recording of behavior, events, or phenomena. Suitable for the research as it can help in observing the behavior and preferences of music professionals and listeners in using the music genre classification system. The observational research can also provide insights into the user experience, interaction, and feedback about the system's accuracy and relevance.

Selection of Data Collection Method (Survey)

Method Selected: Survey Research (Quantitative Research)
Justification: This method is appropriate for the research "Music Genre Classification using Machine Learning" because it allows for gathering data from a large and diverse population, such as music professionals and listeners, to understand their preferences and opinions regarding music genres. The survey method provides a cost-effective and efficient way to collect data and can be conducted online.
The survey research method includes several benefits, such as the capacity to gather data from a sizable sample size, the ability to obtain data from a wide range of individuals, and the capacity to gather data in a timely and inexpensive manner.
Surveys allow for the collection of both qualitative and quantitative data, depending on the type of questions asked. The research involves gathering information about the preferences and habits of listeners and music professionals related to music genre classification. This information can be collected through both closed-ended and open-ended questions, providing a comprehensive understanding of the research problem.

Methodology :

This research employs an Agile software development methodology, providing flexibility for iterative improvement and the integration of user feedback, essential for machine learning researchs requiring extensive testing and validation. Key stages and techniques are structured to ensure that the machine learning model for genre classification is both effective and aligned with user needs.

1. Research Planning

- **Scope and Requirements**: The research scope includes designing a web-based application that automatically classifies music genres using machine learning. During planning, primary stakeholders were established, and the timeline for each research phase was defined.
- **Stakeholder Engagement**: Continuous engagement with stakeholders, including potential users and technical experts, helped refine research objectives and align deliverables with user expectations.

2. Requirement Analysis

- **User Stories and Backlog Creation**: Based on initial requirements, user stories were developed, and a backlog was created to prioritize tasks and define metrics for model accuracy, response time, and usability.
- **Identification of Key Algorithms and Libraries**: This phase involved selecting appropriate machine learning algorithms (K-Nearest Neighbors and Support Vector Machines) and essential libraries (NumPy, Pandas, Sci-Kit Learn) to support efficient model training and deployment.

3. System Design

- **Architectural Blueprint**: The system architecture outlines data flow from feature extraction to classification output, covering modules for data preprocessing, feature extraction, model training, and prediction.
- **User Interface Design**: The web interface is designed to be intuitive, allowing users to upload music files and view classification results in real time. Wireframes and mockups guided the visual and functional design.
- **Database Schema**: SQLite was chosen for efficient storage and retrieval of music data, including classification history, metadata, and feature sets extracted from audio files.

4. Development

- **Model Implementation**: The KNN and SVM algorithms were implemented using Python. The ML models were trained on labeled datasets, with feature extraction techniques like MFCC and chroma features capturing key audio characteristics.
- **Backend Integration**: A Django framework backend was integrated with the ML model to handle requests and return genre predictions.
- **Frontend Integration**: HTML, CSS, and JavaScript were used for the frontend, enabling file uploads and visual feedback on predictions. User interaction data are stored in the SQLite database.

5. Data Collection and Feature Extraction

- **Data Collection**: A diverse dataset of music tracks from multiple genres was curated, fundamental for model training, validation, and testing.
- **Feature Extraction Techniques**: Key features, such as MFCC, spectral contrast, and chroma features, were extracted. These features represent essential musical attributes—rhythm, pitch, and timbre—that aid in differentiating genres.

6. Testing and Validation

- **Model Testing**: The classification model underwent accuracy, precision, and recall testing, with cross-validation techniques ensuring robustness and generalization to unseen data.
- **User Acceptance Testing**: The system was tested by users who provided feedback on classification accuracy, interface design, and overall experience.
- **Continuous Integration**: GitHub Actions facilitated continuous integration, automating testing and deployment for consistent code quality and streamlined updates.

7. Deployment and Maintenance

- **Deployment**: The web application was deployed on a secure server, optimized with caching and efficient data handling for better performance.
- **Maintenance and Monitoring**: Post-deployment, the system is continuously monitored for accuracy and performance, with feedback gathered to update the genre classification model, refine algorithms, and improve user experience based on trends and preferences.

Requirement Verification

Survey Data Analysis

Demographic Data

- **Gender of Respondents**
  Men constituted more than half of the respondents, accounting for 58% of the total, while 38.3% identified as female, and 3.3% identified as other. This demographic breakdown is crucial for identifying the target audience for the system. The research can be tailored to cater to the preferences of the male audience while also considering the interests of female and other identified respondents.
- **Age Group of Respondents**
  The data reveals that 31.7% of respondents belong to the age group of 19-25, 26.7% to the age group of 25-30, 25% to the age group of 30-35, 11.7% to 35-40, and 5% to 40 and above. The largest group, aged 19-25, indicates that the research should focus on the interests and preferences of this younger demographic.
- **Nationality of Respondents**
  A significant majority of respondents (80%) identified as Nepalese, followed by 16.7% who identified as Indian and 3.3% as American. Understanding the cultural background of the respondents is important as it may influence their music genre preferences. For instance, the dominant music genres in Nepal and India differ, which could impact the classification model's performance.
- **Profession of Respondents**
  Among the respondents, 36.7% were music enthusiasts and listeners, 15% identified as musicians with some industry experience, and 13.3% were machine learning professionals. Additionally, 11.7% were data scientists, 18.3% were software engineers, 3.3% were students, and 1.7% were physics teachers. These insights will help tailor the research to the interests and backgrounds of respondents, ensuring a more effective and inclusive system.

Music Preferences of Respondents

The survey data indicates diverse music preferences among respondents. Rock music was the most preferred genre, selected by 46.7%, followed closely by country (43.3%), jazz (40%), and pop (41%). This information is vital for selecting appropriate music samples for training the machine learning models and for testing the classification system against user-favored musical genres.

True/False Data

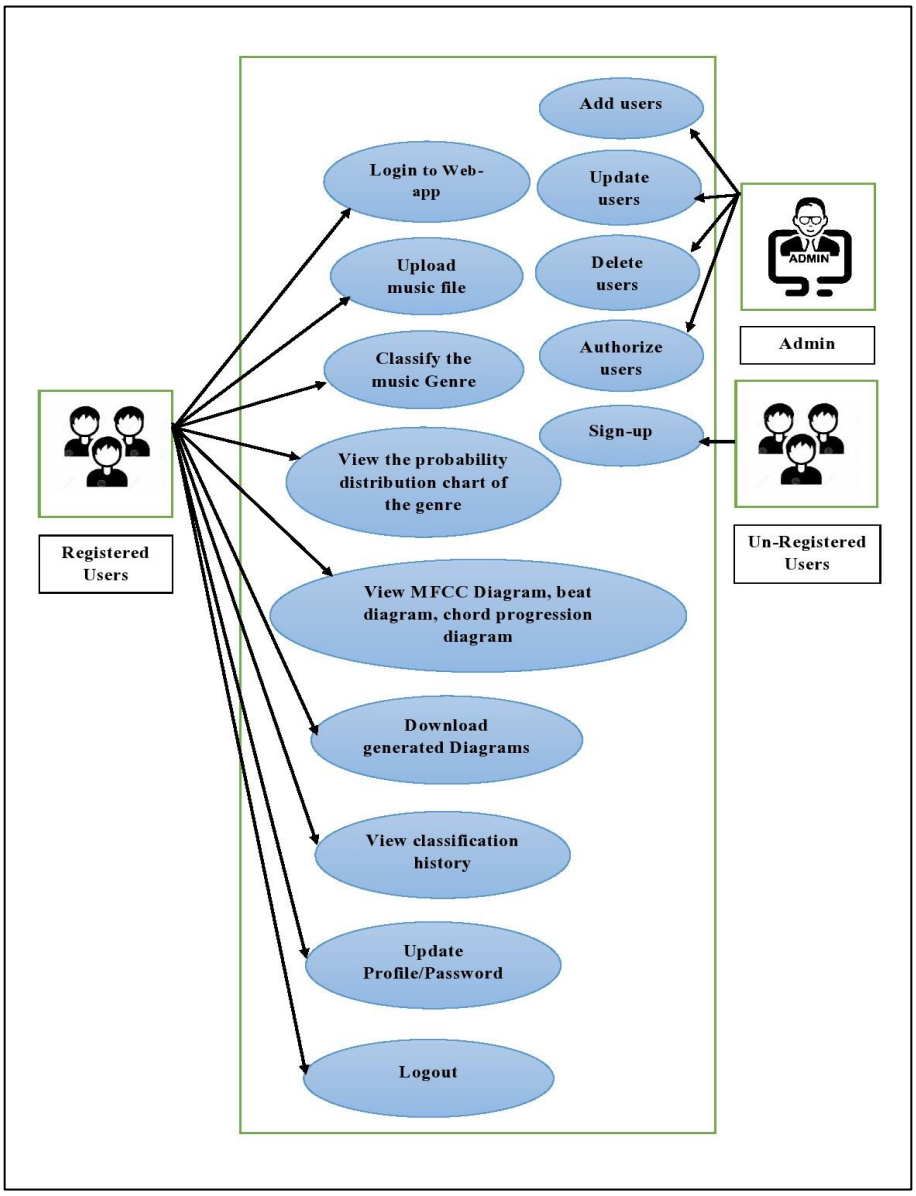
- **Larger Dataset Preference**
  A large majority of respondents (98.3%) agreed that using larger and more varied datasets for training will enhance the precision of music genre classification algorithms. This shows a clear awareness among participants regarding the importance of a diverse dataset in achieving reliable results.
- **Music Culture and Genre Preference**
  The analysis reveals that 65% of respondents believe that music genre classification models can exhibit biases toward certain music cultures and genres, while 35% disagreed. This finding suggests that addressing potential biases is essential when developing the classification models.
- **Sub-genre and Hybrid Genre Preference**
  Eighty-five percent of respondents feel that music genre classification models should accurately identify sub-genres and hybrid genres. This highlights a strong interest in detailed classification, while 15% disagreed, indicating that not all respondents find such specificity necessary.
- **Consideration of Intended Audience**
  Approximately 91.7% of respondents believe that the classification models should consider the intended audience or context of a music track.

This indicates a need to incorporate contextual information in developing music genre classification models.

Likert Scale Questions

- **Machine Learning Accuracy**
  Out of 60 respondents, 33 agreed and 15 strongly agreed that machine learning is accurate at identifying music genres, totaling 48 respondents. This reflects growing confidence in the use of ML models for classification.
- **Cultural Variation in Music Style**
  The survey shows that 32 respondents agree and 12 strongly agree on the importance of considering cultural variations in music styles for genre classification. This indicates a recognition of cultural sensitivity in model development.
- **Importance of Audio File Patterns**
  The majority of respondents agree that considering the features and patterns of an audio file is crucial for developing music genre classification models. This underscores the necessity of accurately selecting audio features in differentiating music genres.
- **Diversity of Dataset**
  Many respondents acknowledge that the accuracy of classification models can be affected by the diversity and size of the training dataset. This reinforces the significance of extensive and varied datasets in achieving effective model training.
- **Listener's Music Preference**
  About 57.5% of respondents believe that music genre classification can be subjective, depending on individual musical preferences. However, 26.7% disagreed, suggesting the presence of objective criteria for genre classification.
- **Temporal Variation in Music**
  The data indicates that most respondents agree on the need to consider temporal variations in music styles for genre classification models, emphasizing the challenge of adapting to rapidly evolving music styles.
- **Consideration of Moods and Emotions in Music**
  Responses suggest a lack of consensus on the importance of moods and emotions in genre classification, indicating diverse opinions on their relevance to the task.
- **Audience Consideration**
  The majority (71.1%) agree that considering the intended audience is crucial for music genre classification, emphasizing the influence of audience background on categorization.
- **Consideration of Production and Recording Techniques**
  A significant number of respondents believe that production and recording techniques should be considered in music genre classification models, indicating a recognition of their impact on genre determination.
- **ML for Classifying Instrumental Music**
  The data reveals that a substantial number of respondents believe machine learning can effectively classify music genres even for instrumental tracks, showing confidence in ML's pattern recognition capabilities.
- **Consideration for Identifying Emerging Genres**
  A widespread recognition of the importance of keeping up with music trends is reflected in the responses, with many agreeing on the necessity of identifying emerging genres.
- **ML Abilities**
  The survey indicates some agreement that the age and era of a music track can influence genre classification, highlighting the potential impact of historical context on classification accuracy.
- **Regional Music Origin**
  Responses suggest recognition of the importance of cultural context and geographic origin in music genre classification, indicating that these factors should be incorporated into model development.
- **ML Accuracy**
  Most respondents believe machine learning can accurately classify genres for live performances and improvisational music, indicating confidence in ML's adaptability to dynamic settings.
- **Consideration on Music Recording Quality**
  A majority believe that the recording quality and format of a music track can influence its genre classification, stressing the importance of technical aspects in the classification process.
- **Consideration of Arrangement of Music Track**
  A significant majority agree on the importance of instrumentation and arrangement when classifying music genres, emphasizing how these elements contribute to genre determination.
- **Tempo and Rhythm Consideration**
  Most respondents acknowledged the relevance of tempo and rhythm in genre classification, reflecting an understanding of how these musical elements affect categorization.

The Web-based Music Genre Classification System is an innovative application that leverages machine learning algorithms to classify songs based on their genre. This system provides a user-friendly interface for music professionals and listeners, allowing them to upload audio files and receive accurate genre classification results. The primary goals are to enhance personalized music experiences, enable genre-specific playlist creation, and facilitate integration with other applications, such as music recommendation systems and production tools. The core features and components of this system are outlined below.



i. Web Application

The system is designed as a web application, accessible through standard web browsers. It features a seamless and intuitive interface that enables users to interact with the music genre classification functionality. Users can upload audio files, view classification results, and access their classification history. The application also provides options to download various analytical diagrams, including MFCC (Mel-Frequency Cepstral Coefficients) diagrams, beat diagrams, and chord progression diagrams.

ii. Genre Classification

At the heart of the system is its ability to accurately classify music tracks into various genres. This classification is achieved through the training of machine learning models, which learn patterns and characteristics specific to different musical genres. The models are trained using large datasets, such as GTZEN, which contains annotated audio tracks spanning diverse genres. This ensures that the classification results are both precise and reliable.

iii. User Interface

The user interface is designed to be intuitive, allowing users to easily interact with the genre classification functionality. Users can upload audio files via simple file upload options, and the interface presents genre classification results in an organized and visually appealing manner. This ensures a smooth user experience, making it easy for individuals to engage with the system.

iv. Personalized Playlists

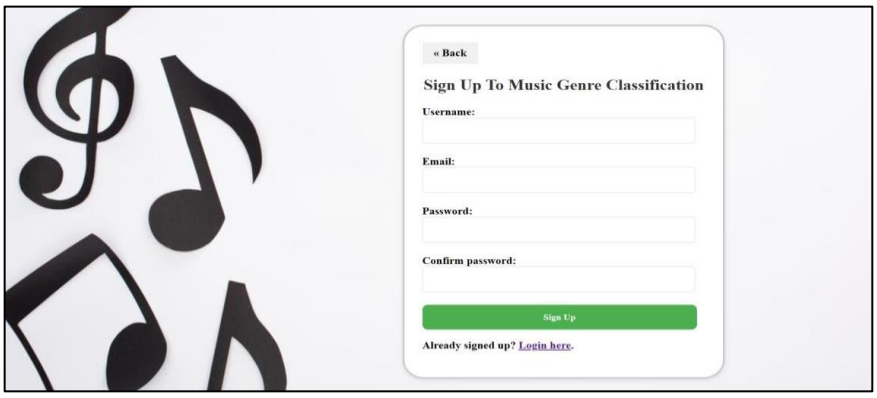
A key objective of the system is to facilitate the creation of personalized, genre-specific playlists. By accurately classifying music tracks, users can build playlists tailored to their musical preferences. This capability enhances the overall listening experience, enabling users to discover new songs within their preferred genres and enjoy a more customized musical journey.

Use-case Diagram

The use-case diagram for the "Music Genre Classification Using Machine Learning" research showcases the interactions between users and the system. It represents key functionalities such as user login, music file upload, genre classification, and viewing classification history. The diagram provides a high-level overview of the system's use cases and the actors involved in the process (Campbell, 2017).

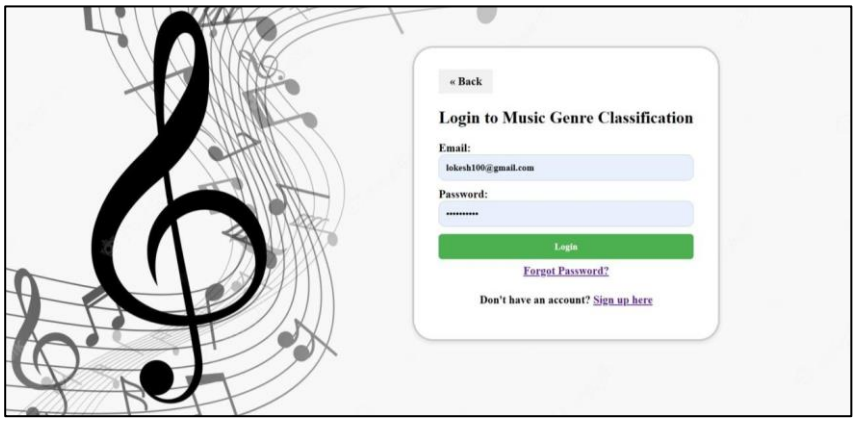
Sign-Up page

To get started with the system, users enter their desired username, ensuring its uniqueness across the system. Next, they provide a valid e-mail ID that will serve as their login credential. System's robust validation system will ensure that the username and e-mail address are unique and not already registered. To enhance security, password validation enforces a strong password policy. A minimum of 8 characters must be included in the user's password, with a combination of capitals, lowercase form, digits, and unique characters.



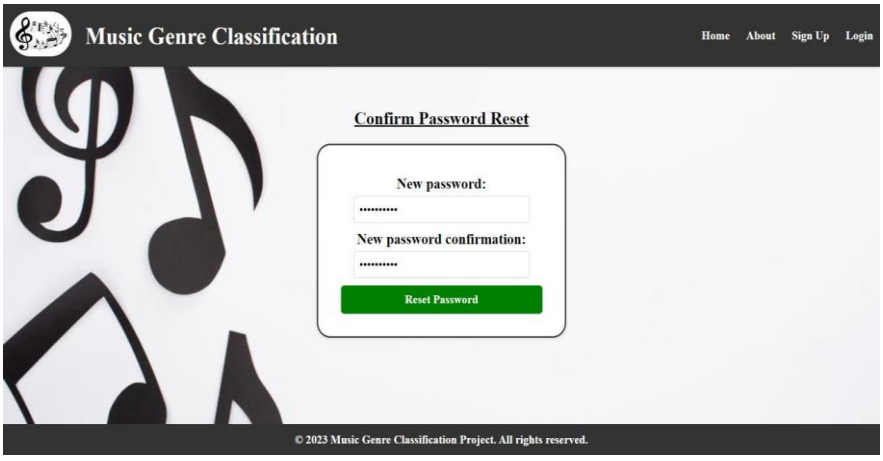
Login Page

Upon visiting the Login page, users are prompted to enter their registered e-mail address and password. The system then verifies the provided information against system's encrypted database. In case of any discrepancies, an error message is generated, safeguarding user accounts from unauthorized access. If a user forgets their password, the system's password recovery option allows users to reset their passwords securely, granting access back to their accounts without any hassle.



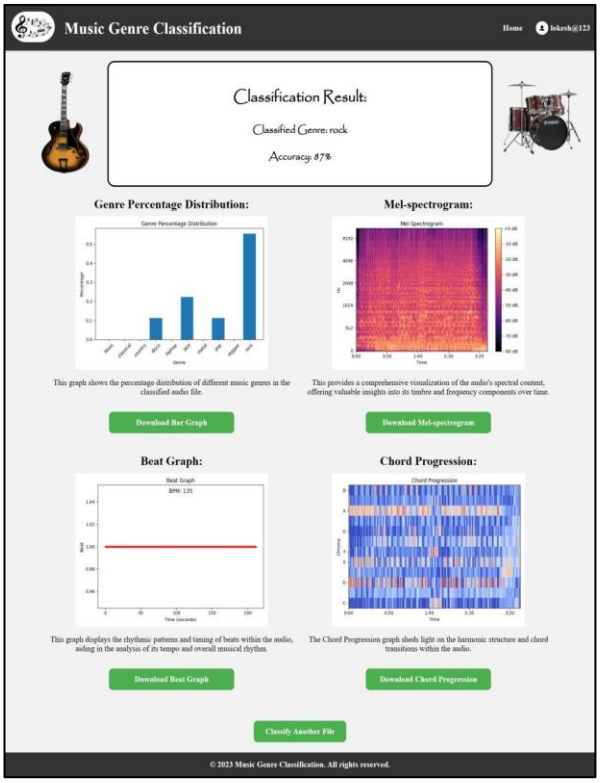
Forgot Password

Users can reset their passwords using the "Forgot Password" form and their registered email addresses. Following submission, a special link to reset the user's password is generated and delivered to their email, guaranteeing secure access. The link has a limited lifespan and expires after a certain amount of time for enhanced protection. Users clicking the link are taken to a secure page where they can create a new password. Users get a confirmation message after submitting their request successfully, verifying the password reset. User experience is given priority in this approach, and user information and privacy are both protected.



Result Page

The Result Page displays the music file's genre classification outcome and accuracy. It presents the identified genre, confidence level, and a Genre Probability Distribution Chart for visual insights. The Mel-spectrogram chart illustrates acoustic features, while the Beat Diagram showcases rhythmic structure and tempo. The Chord Distribution Graph displays harmonic progression. Visualizations aid users in understanding underlying musical traits. Users can download all generated graphs for analysis and record-keeping. The Result Page aims to engage users in music genre classification exploration.



Research Overview :

The "Music Genre Classification using Machine Learning" research presents a comprehensive approach to developing a web-based system that categorizes music files into distinct genres. Grounded in extensive research, this initiative showcases a commitment to understanding user needs, integrating advanced technologies, and adhering to best practices in software development.

Strengths

1. **Thorough Research**: The research is supported by an extensive literature review, encompassing 18 research sources. This foundation not only affirms the research's relevance but also enhances the credibility of its findings and methodologies.
2. **Technological Stack**: Utilizing Python for development and Visual Studio Code as the Integrated Development Environment (IDE) underscores the research's focus on flexibility and usability. SQLite as the database management system further aligns with the research's aim for a lightweight and efficient solution.
3. **Agile Methodology**: The choice of the Agile system development methodology allows the team to adapt to evolving requirements effectively. This iterative process encourages collaboration and continuous feedback, which are vital for the research's success.
4. **User-Centric Approach**: By employing research techniques such as surveys and questionnaires, the research prioritizes user feedback. This commitment to understanding user preferences ensures that the developed system is tailored to meet the actual needs of its target audience.
5. **Robust Testing Framework**: The research includes a comprehensive testing phase that encompasses unit testing, integration testing, usability testing, and user acceptance testing. This thorough approach to validation ensures the system's functionality and usability in real-world contexts.
6. **Innovative Visualizations**: The inclusion of various music statistical diagrams, such as Mel-spectrograms and genre probability distributions, enhances user engagement and provides deeper insights into the classification process.

Weaknesses and Areas for Improvement

1. **Algorithm Exploration**: While K-Nearest Neighbors (KNN) is employed for genre classification, the research could benefit from exploring other algorithms, such as Support Vector Machines (SVM) and deep learning approaches like Convolutional Neural Networks (CNN), which may yield improved accuracy.
2. **Dataset Expansion**: The system's performance could be enhanced by integrating additional music datasets. Collaborating with external music libraries or APIs would diversify the genres and potentially improve classification accuracy.
3. **Broader User Feedback**: Engaging a wider audience for testing and feedback could provide valuable insights. This includes music enthusiasts

and industry professionals from various backgrounds to further refine the system.

4. **Enhanced Visualization Features**: While the current visualizations are beneficial, expanding these features could provide users with an even more comprehensive analysis of music statistics, thereby enriching the overall experience.

Conclusion :

At the culmination of the "Music Genre Classification using Machine Learning" research, a robust and user-friendly web-based system for music genre classification was successfully developed. The research achieved its primary objective of creating a platform where users can upload music files and have them accurately classified into various genres. The system incorporates Python as the programming language, VS Code as the IDE, and SQLite as the database management system, laying a solid technological foundation. Through extensive literature and system reviews, technical research, and user-driven requirement validation, the research ensured alignment with user needs and preferences. Thorough testing was conducted to ensure system reliability and performance, offering a seamless user experience, accurate genre classification using the K-Nearest Neighbors (KNN) model, and insightful music statistical visualizations. With its successful implementation, the research stands as a commendable achievement, catering to the needs of music enthusiasts, producers, and artists alike.

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