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(Research Article)

Classification of music genre using support vector machine and convolutional neural network

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Abstract

Music is an art of combining rhythms, melodies, harmony, and form and also an art of expressing content. Almost all people in this world love Music. This depends on the person and what type of Music he likes to listen to. Either it will be Classical, melodious rock Hip-hop, or some other class of genre. The task of classifying music files based on genre is extremely difficult, especially in the area of MIR (Music Information Retrieval). The approach involves deep learning, where CNN and SVM models are trained end-to-end using a spectrogram to classify a signal's genre label. Every person has a different choice. In this paper, a set of Music is classified into different types of genres with the help of machine learning. A set of 1000 audio files containing 10 types of genres, with 100 audio files each has been taken. The audio features have been extracted using the Spectral roll-off, Chroma features, and zero Crossing Rate. Then, the model was predicted using different algorithms like Support Vector Machine (SVM), and Convolutional Neural Networks (CNN). After the model is predicted using the algorithms, CNN outperformed SVM and gave an accuracy of 96.2%.

Keywords: Music genre; Machine Learning Model; Feature extraction; Support Vector Machine; Convolutional Neural Network.

1. Introduction

A music genre classifier is a piece of software that identifies the genre of an audio recording. These devices are used for a variety of tasks, such as automatically categorizing songs for Spotify and Billboard and selecting the appropriate background music for events. Currently, genre classification is carried out manually based on the individual musical interpretation of each person. Traditional computer methods have not yet been able to automate this task since music genre distinctions are sometimes arbitrary and subjective. However, because genre classification is unclear, machine intelligence is best suited to this task. Given enough audio data, which is easily obtainable in large amounts from music that is available for public consumption on the internet, machine learning can recognize and predict using these imprecise patterns. The goal of this paper is to create a proof-of-concept deep learning-based music genre classifier that can reliably identify the genre and confidence level of Western music among four candidate genres (classical, jazz, rap, and rock).

One of the trickiest problems in data science is audio processing, especially when compared to other classification methods like image processing. One such tool that aims to classify audio files into the proper sound groupings is music genre categorization. This application is essential and requires automation to reduce human error and time spent classifying the music because one must listen to each file through once if we have to do it manually. Therefore, in order to automate the process, we will use machine learning and deep learning algorithms in this essay.

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Music acts as a reliever for many peoples. The listeners differ from each other by the choice of genre of music they like. So, using machine learning, a model is prepared to classify the audio files on the basis of genres. The dataset for this paper has been downloaded from GTZAN Genre Classification dataset which consists of 4 files, one files is for the genre originals, one for images originals, and two csv files. In the genre's originals file, there are 10 types of genres, each represented by 100 tracks, which in total is 1,000 audio files, each of 30 seconds long. At first, an audio file has been chosen. Features of the audio files have been extracted using the plot of wave form of the audio file and spectrogram of the audio file. Chroma features of the audio file have also been drawn. EDA (Exploratory Data Analysis) has also been done which shows the visualization of audio files of different genres and the wave form and mel spectrograms of the audio. Then the dataset has been divided into training and testing dataset. Different algorithms are then applied on the model to test the accuracy. In this paper, sound files are handled in python, and sound and audio features are computed.

Music genres categorize music based on shared characteristics like rhythm, instrumentation, cultural influences, and themes. Here's an overview of some common music genres:

- Rock: Originating from rock and roll in the 1950s, rock music often features electric guitars, drums, and strong rhythms. Subgenres include classic rock, punk rock, alternative rock, and more.
- Pop: Popular music characterized by catchy melodies, simple song structures, and a wide appeal to the general audience. Pop music frequently dominates the mainstream charts.
- Hip Hop/Rap: Emerging in the 1970s, hip hop emphasizes rhythmic and rhyming speech. It often includes elements like Ding, rapping, and beat boxing. Rap focuses on spoken or chanted lyrics.
- Electronic/Dance: Utilizing electronic instruments and technology, this genre emphasizes synthesized sounds and danceable beats. Subgenres include techno, house, trance, dub step, and more.
- Jazz: Known for its improvisation and swing rhythms, jazz encompasses various styles like smooth jazz, bebop, fusion, and Dixieland.
- Classical: Spanning centuries, classical music includes compositions from different periods (e.g., Baroque, Romantic, Classical). It features orchestras, chamber ensembles, and solo instruments.
- Country: Originating in the rural American South, country music emphasizes storytelling, acoustic instruments (like guitars and fiddles), and themes like love, heartache, and rural life.
- R&B/Soul: Rooted in African American musical traditions, rhythm and blues (R&B) and soul music often feature powerful vocals, emotional performances, and influences from gospel and blues.
- Reggae: Originating in Jamaica, reggae music emphasizes a strong backbeat and off-beat rhythms. It often addresses social and political issues.
- Folk: Reflecting cultural traditions and often performed with acoustic instruments, folk music includes various regional and cultural styles.

These genres represent a fraction of the diverse musical landscape, and many genres have subgenres or hybrid forms that blur the lines between categories. Musical genres evolve and blend over time, resulting in a rich tapestry of musical expression across the globe. The proposed methodology of our paper, which includes subsections of hardware required, software required, and algorithms and libraries used.

2. Literature Survey

The CNN (Convolutional Neural Network) used in the Neural Method technique is guided from beginning to end by the features of the audio signal's spectrograms, or pictures. The second method uses numerous machine learning (ML) methods [2], including random forests and logistic regression, among many others. The physical characteristics that are extracted include spectral features, chromatic features, and MFCCs (mel-frequency cepstral coefficients). The author's entire body of work provides us with a method for automatically classifying music by assigning different tags to each song that is in the user's collection. It examines the use of ML (Machine Learning) algorithms in both the conventional and neural methods to accomplish their goals.

In the classification of audio content analysis. an audio stream is segmented based on the speaker's identity or the type of sound. The primary method they employ is building a strong model that can effectively separate and classify audio signals into speech, music, ambient sound, and silence. There are two primary processing phases for this classification, which have also made it suitable for a wide range of additional applications. Discrimination between speech and non-speech is the initial stage. Here, a unique approach that primarily relies on KNN (K-nearest-neighbor) and linear spectral pairs-vector quantization (LSP-VQ) has finally been devised. [3].

2.1. Materials and Methodology

Figure 1 represents the methodology of our paper in flow chart form.

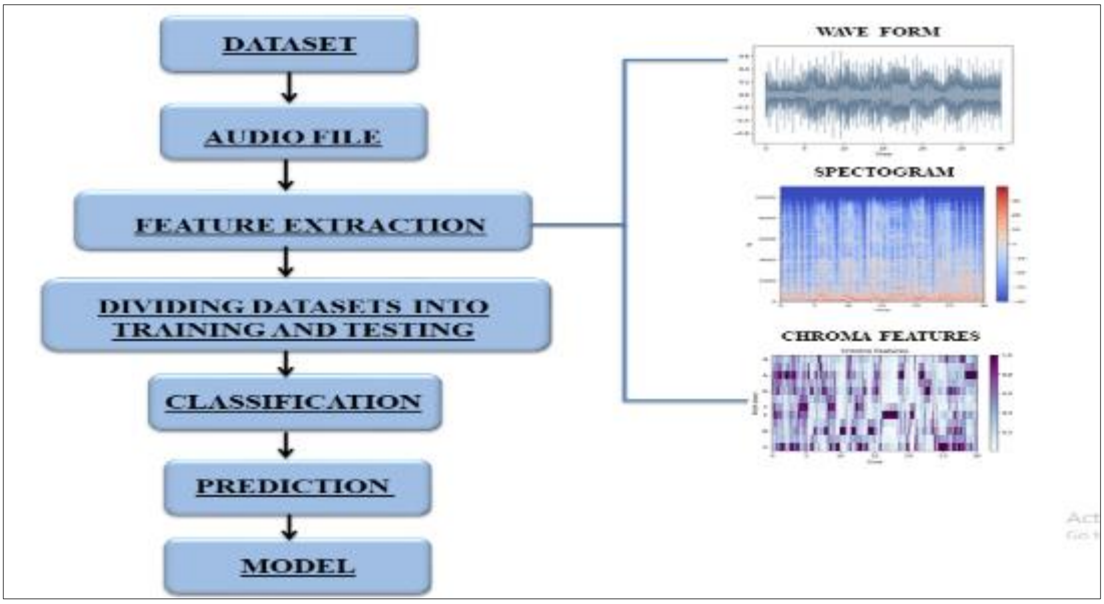

Figure 1 Workflow of the proposed model

3. Algorithms Used

3.1. Support Vector Machine

Support vector regression is one of the most used supervised machine learning algorithms. Classification problems are the typical use for it. Nonetheless, it can be used for both regression and classification problems. The goal of this algorithm is to create hyperplanes. A hyperplane is the best line or decision boundary to use for splitting n-dimensional space classes into discrete categories. This will help with future data point classification. Support vectors are extreme points or vectors chosen by Support Vector Machine (SVM) that help create the hyperplane. The principle of support vector machine (SVM) for regression is a supervised machine learning method. SVM makes a decision boundary by which the greater part of the data points of the relevant kind falls on the same side of the boundary. Let us consider the data points of an n-dimensional feature vector space

X = (x_1, x_2, ... … ... ,x_n), from which we construct a hyper plane

$\alpha_0 = \sum_{j=1}^{n} \alpha_j x_j = 0$, where the boundary of the optimal hyperplane can be obtained by the maximizing the distance from any point to the plane. The maximum margin hyperplane (MMH) separates the similar types of data points. The necessary feature is that only neighbouring points to the boundary of the hyperplane are participated in selection keeping all other points as it is. These points are well-known as the support vectors, and support vectors are separated in respective class by a hyperplane, which is called the Support Vector Classifier (SVC). The inner products of support vector classifier are weighted by their labels, and it helps to maximize the distance from support vectors to the hyperplane.

The fundamental perception of SVM is to maximize the hyperplane margin in the feature space. The Support Vector Machine for Regression (SVR) model is a supervised machine learning technique is described below. Given a sample data-set S = (x_1; y_1); (x_2; y_2); ::: ::: (x_l; y_l) representing l input-output pairs, where each $x_i \in X \subset R^n$, where X represents the n dimensional input sample space and matching target values $y_i \in Y \subset R^n$ for i = 1, 2, … … l, where l is the size of the training data. The purpose of this regression problem is to construct a function $f : R^n \rightarrow R$, to approximate the value of y for unseen data x, which was not participated in training sample. By taking a nonlinear function ϕ, the input data is mapped from R^n to a high dimensional space R^m , m > n, and consequently the estimation function f is defined as

$$f(x) = (w^T \varphi(x)) + b \quad (1)$$

where $w \in R^m$ is the regression coefficient vector, $b \in R$, is the bias or threshold value. The main intention of the support vector regression is to build a function f which has the most ϵ-deviation from the target y_i .We need to find w and b for which the value of f(x) can be obtained by minimizing the risk

$$R_{reg}(w) = \frac{1}{2}\|w\|^2 + C\sum_{j=1}^{l} L_\varepsilon(y_j, f(x_j)) \quad (2)$$

where C is the user defined penalty factor, which determines the trade-off between the training error and the penalizing term $\|w\|^2$ *and* $\sum_{j=1}^{l} L_\varepsilon(y_j, f(x_j)$ is the ϵ-intensive loss function originally proposed by Vapnik et al, which is defined as

$$L_\varepsilon(y_j, f(x_j)) = \begin{cases} |y_j - f(x_j)| - \varepsilon, & |y_j - f(x_j)| \geq \varepsilon \\ 0, & |y_j - f(x_j)| < \varepsilon \end{cases} \quad (3)$$

The minimum risk functional equation (2) can be reformulated by introducing non-negative slack variables γ_j *and* ξ_j as

$$R_{reg}(w, \gamma_j, \xi_j) = Minimize - \frac{1}{2}\|w\|^2 + C\sum_{1}^{l}(\gamma_j + \xi_j) \quad (4)$$

$$\text{subject to constraints} \begin{cases} y_j - w^T x_j - b \leq \varepsilon + \gamma_j \\ w^T x_j + b - y_j \leq \varepsilon + \xi_j \\ \gamma_j, \xi_j \geq 0 \end{cases} \quad (5)$$

where $\frac{1}{2}\|w\|^2$ is the regularization term preventing over learning $(\gamma_j + \xi_j)$ is the realistic risk and C > 0 is the regularization constant, that controls the trade-off between the empirical risk and regularization term. By introducing Lagrange multipliers α_j, β_j, μ_j *and* η_j the quadratic optimization problem (4) and (5) can be formulated as

$$L = \frac{1}{2}\|w\|^2 + C\sum_{1}^{l}(\gamma_j + \xi_j) - \sum_{j=1}^{l}\alpha_j(\varepsilon + \gamma_j - y_j + w^T x_j + b) - \sum_{j=1}^{l}\beta_j(\varepsilon + \xi_j + y_j - w^T x_j - b) - \sum_{j=1}^{l}(\mu_j\gamma_j + \eta_j\xi_j) \quad (6)$$

The dual of the corresponding optimization problem (4) and (5) is represented as Maximize

$-\frac{1}{2}\|w\|^2 + C\sum_{j,k=1}^{l}(\alpha_j - \beta_j)(\alpha_k - \beta_k)(x_j)^T x_k - \varepsilon\sum_{j=1}^{l}(\alpha_j + \beta_j) + \sum_{j=1}^{l}(\alpha_j - \beta_j)$ Subject to constraints $\begin{cases} \sum_{j=1}^{l}(\alpha_j - \beta_j) = 0 \\ \alpha_j, \beta_j \in [0, C] \end{cases}$ By changing the equation $w = \sum_{j}^{l}(\alpha_j - \beta_j)x_j$,the function f(x) can be written as

$$f(x) = \sum_{j}^{l}[\alpha_j - \beta_j]^T \varphi(x) + b \quad (7)$$

accordingly by applying Lagrange theory and Karush-Kuhn-Tucker condition, the general support vector regression function can be expressed as $f(x) = \sum_{j}^{l}(\alpha_j - \beta_j) K(x_j, x_k) + b$ (8)

where $K(x_j, x_k)$ known as Kernel function. The value of kernel function is equal to the inner product of x_j and x_k in the feature space $\varphi(x_j)\, and\, \varphi(x_k)$ such that $K(x_j, x_k) = \varphi(x_j).\varphi(x_k)$ (9)

3.2. Convolutional Neural Networks

It is simple to understand the numerous significant characteristics that often go into creating the ideal model used for music genre classification. CNN (Convolutional Neural Network) can be used in a novel way to extract the audio file's musical pattern features. One can survey the different opportunities for CNN's application in MIR (Music Information Retrieval). Based on numerous studies and findings, it can be said that CNNs (Convolutional Neural Networks) have the greatest ability to extract informative characteristics from diverse musical patterns. CNN is a deep-learning algorithm used for image recognition and classification [4-60]. Convolutional, pooling and fully linked layers are its three constituent layers. The essential part of a CNN is the convolutional layers. A sizable dataset of tagged photos is used to train CNNs so they can identify patterns and characteristics linked to particular items or classes. CNN can be used for feature extraction for use in other applications or for the classification of new pictures. The performance of CNNs on a variety of image identification tasks is state-of-the-art. It is a deep learning neural network designed to handle structured data sets, like representations. Their ability to discern the design in the input image is highly satisfactory. CNN does not require any preprocessing and can operate straight on an underdone image. The convolutional layer of the CNN is its strongest component. In CNN, numerous convolutional layers are stacked on top of one another. Different types of CNN models are LeNet, AlexNet, ResNet, GoogleNet, MobileNet, and VSG.

4. Result and Discussions

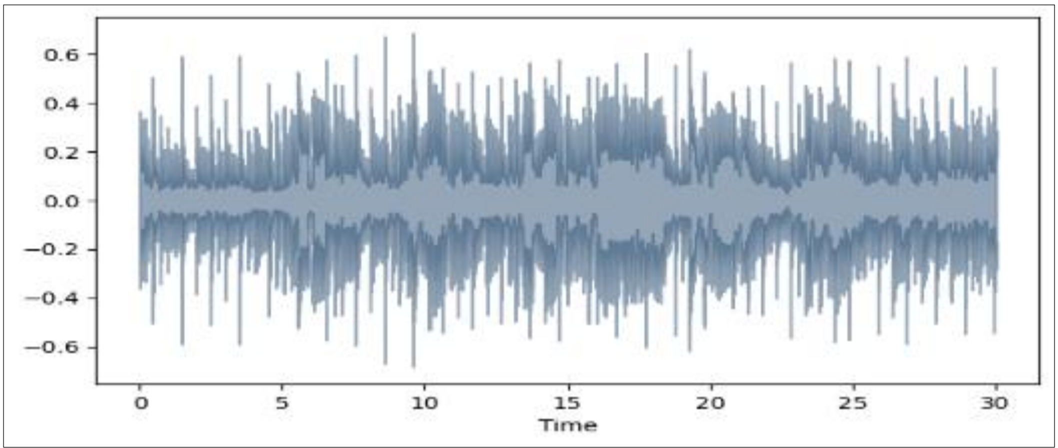

Figure 2 Wave form of audio files

Wave forms of an audio file are the simple graphs of an audio file which shows the comparison between the frequency and amplitude over time. The taller the waveform is, the higher the amplitude, thus, louder the sound at that frequency. So, here a random audio file is taken from the dataset and the wave form of the audio file is found.

Twelve distinct pitch classes are closely associated with the phrase "chroma feature." Another name for it is "pitch class profiles," and it's an effective tool for music analysis. This is graph of the chromatic features or the pitch class over the time. The darker is the colour the higher is the pitch.

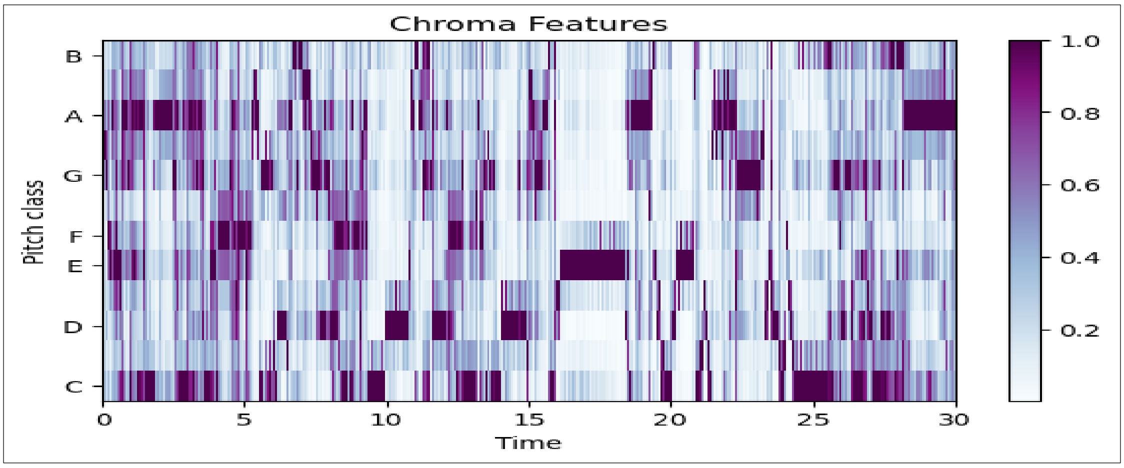

Figure 3 Chroma Features of audio files

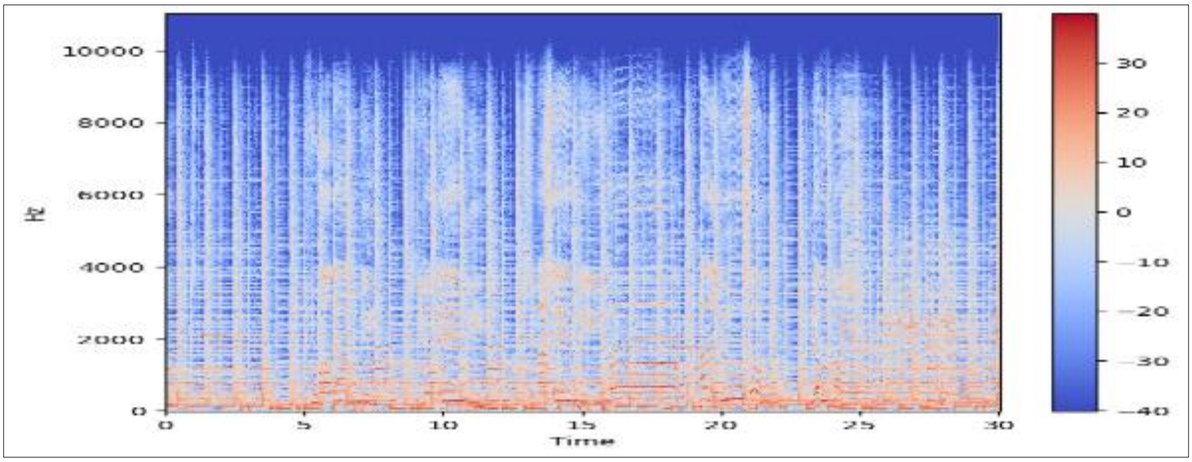

Figure 4 Spectrogram features of audio files

A spectrogram is a graphic tool that shows the signal strength or "loudness" at various frequencies within a given wave form over time. All that's involved is a graph that accurately depicts audio and has the ability to display frequency, amplitude, and time all at once. Using this graph frequency energy distribution over a particular time can be known. With the help of this, the sound elements in a recording or an audio file and the harmonic structure can be distinguished.

4.1. Exploratory data analysis (EDA)

Data is examined using exploratory data analysis (EDA) to look for trends, patterns, or to confirm hypotheses with the help of statistical summaries and graphical representations. In this, the audio files, spectrograms and wave plots are visualized for all the 10 genre classes.

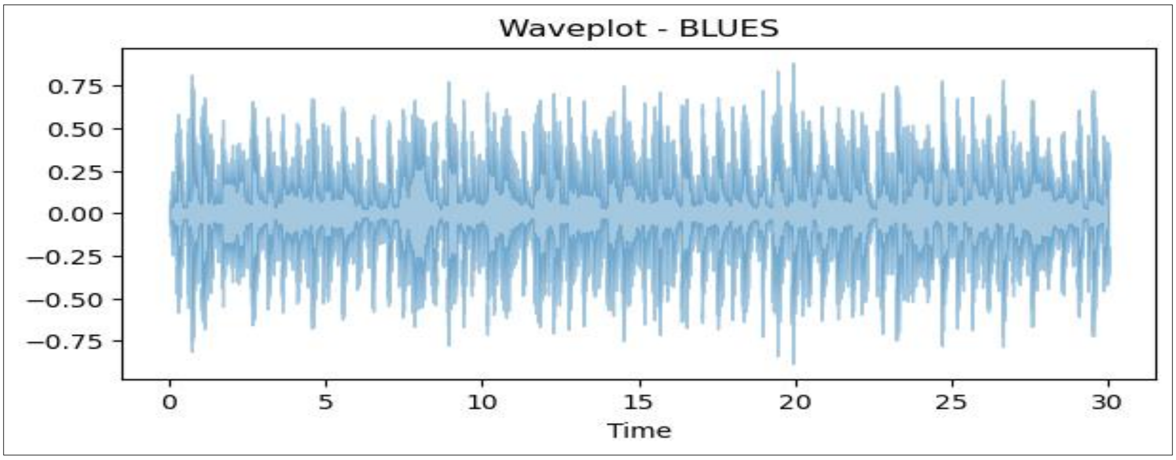

Figure 5 Visualization of spectrograms and wave plots of different genres

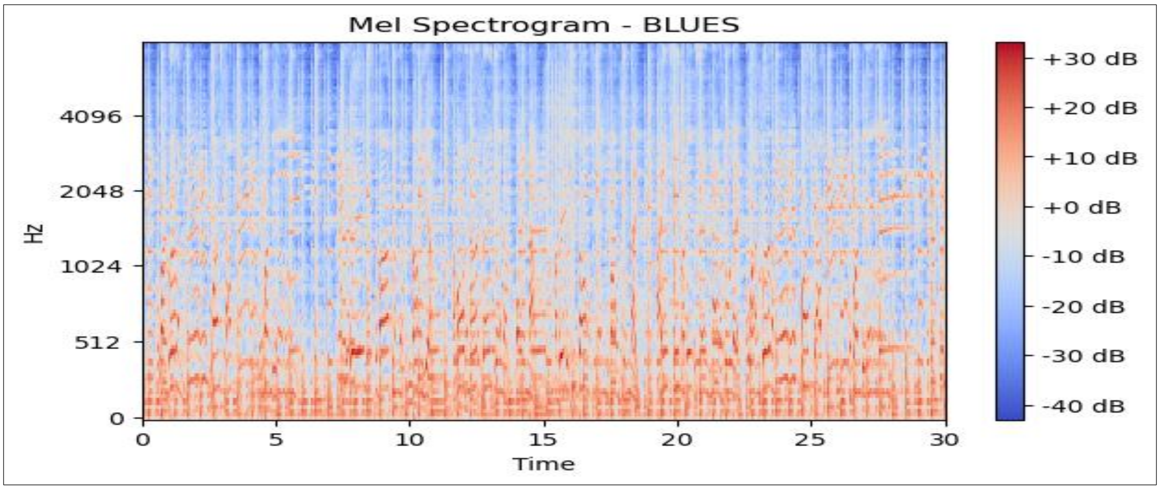

Figure 6 Visualization of wave plot and mel spectrogram of different genres

SVM is one of the best machine learning models. It is used when the data is nor linearly separable. So, sigmoid function has been used as SVM kernel function. The sigmoid function is given by

K(yn,yi) = tanh(-gamma*(yn,yi)+r)

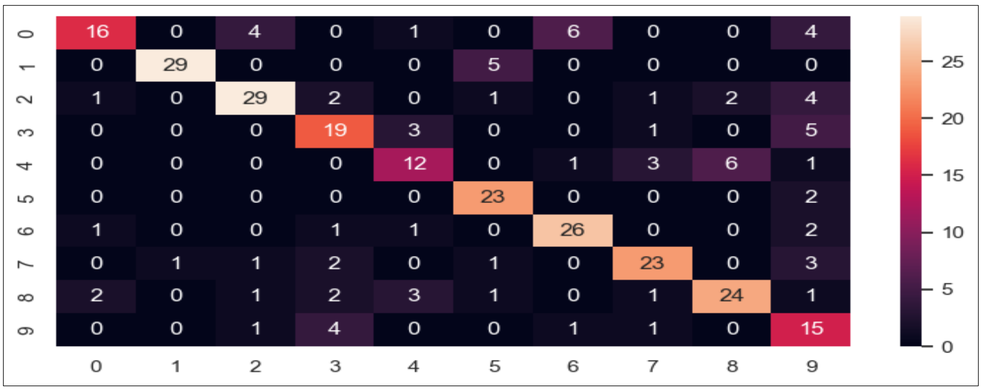

Figure 7 Confusion matrix of different music genre

The Extreme Gradient Boosting Confusion Matrix shows the relative importance of the features in the XGBoost model; the models are assessed and the top 20 features are shown. First, AUC is used to evaluate the models, followed by accuracy and F-score.

5. Conclusion

This paper shows the extraction of the features of the audio files, with the help of plotting different graphs. First the wave form of a random audio file has been drawn, and then the graph for the Chroma features of the audio file which refers the pitch class. Spectrogram has been drawn, which represents the graph of the loudness comparing the frequency over time. Then exploratory data analysis (EDA) has been done for all the 10 types of genres, which includes the wave plots, spectrograms, and visualization of the audio file. At last, the prediction of the model has been done using support vector machine algorithm and k-nearest neighbours' algorithm and drawn the confusion matrix of both. As a result, CNN algorithm outperformed SVM algorithm and gave an accuracy of 96.2%.

Compliance with ethical standards

Disclosure of conflict of interest

There is no conflict of interest among the authors.

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