Urdu Music Genre Classification Using Convolution Neural Networks

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***Abstract*—Music is a form of art whose medium is organized sound. Communities from all parts of the world can be identified by their songs they listen to and compose. Music is often classified into different genres. The goal of this paper is to discover a machine learning algorithm that efficiently classifies music. Our research focuses on the genre classification of Urdu music, which is native to Pakistan. In order to compare performance, different classification models were constructed and trained over the Urdu dataset we created using several methods, mainly focusing on convolution neural networks. This dataset was based on only Mel-Frequency Cepstral Coefficients images of audio tracks. The performances were compared in terms of validation accuracies of models and loss produced by Sparse Categorical Cross Entropy Loss function. Our model based on CNN with batch normalization gave us a higher level of accuracy of 92.6% with a low loss of 0.0051, compared to other methods.**

***Index Terms*—machine learning, classification, convolution neural networks, deep learning, mel-frequency cepstral coefficients, urdu music genres**

I. Introduction

Classification is a type of supervised learning in which the input data is also delivered to the objectives. Models can adapt and learn classification tasks to help better understand diversity. This allows us to use these Deep learning models for different tasks. Deep learning models have numerous uses in a variety of fields, including credit approval, biological disease diagnosis [28], and target marketing. Music is another field where deep learning models can be applied for classification.

Music has always played an integral part in people's lives and now, it has become more dominant than ever [1]. Music is an ever evolving discipline because new additions are being made to it every single day. However, different individuals prefer different types of music and this is what gives birth to **Music Genres**, that is a classification system which places different musics into neat categories based on some metrics [9].

Music classification is commonly used by audio distribution platforms such as Soundcloud, Saavn, Spotify etc. These companies use this classification as a tool that could determine recommendations for their users, or as a product of music search [22]. In order to perform such tasks, it is vital to know the genres of music. Therefore, the analysis of music occurs where machine learning algorithms come in play.

The division of music into classes may be considered subjective [24], however, there are non-cognitive standards which are the basis of Music's analysis, that help determine genres of music. This analysis is on a song's electronic badge for some features that include tempo, rhythm, energy, acoustics, speed etc. Genres of music are set apart by the common attributes shared by the members of each category. These attributes include rhythm, pitch instrumentation, harmony and texture of music [23]. Music genre classification is typically done manually for digitally accessible music. Therefore, procedures for computerized genre classification will prove to be an exceptional incorporation to the digital entertainment industry and audio information retrieval systems [24].

Furthermore, the relevance of music genre classification is prominent in the solving of certain tasks. For instance, creation of music reference, pursuing related music, determining communities or societies that will be interested in a particular music [25] and it may also prove to be helpful in survey schemes.

The classifier built in this research is the first of its kind to be capable of classifying Pakistani local music. So, the chosen set of genres for the research does not only include globally known ones, but some that are native to Pakistan as well. Thus, in our research, we wanted to make a deep learning model that when given a Urdu music file, can classify its genre, based on just one feature of the audio: MFCCs. Secondly, the data that has to be used to train this model was not available. We have created a new valid and authentic dataset based on music present only in Pakistan. The purpose of this paper is to create a new dataset based on Pakistani music, explore the previous work done in music genre classification and then build up on it, concluding with the best approach.

II. Music Genres

Addition to previously mentioned attributes, music exhibits certain generic forms of chord progression, key, melody, lyric and mood. It is by analyzing the musical and lyrical content and structures that music can be categorized into genres. [10] Genres relevant to our research are mainly: Rock, Hiphop, Ghazal and Qawwali.

- **Rock** heavily relies on rhythm sections which creates a 'bombastic' beat. The instruments most commonly heard in rock rhythm are drums, bass guitar, electronic guitar, and acoustic guitars. The speed is usually fast-paced from the get-go. [13]
- **Hiphop** is as a music genre consisting of stylized rhythmic music with beat mixing/matching, juggling, accompanied with rhythmic and rhyming speech. The typical instruments heard in hiphop music are turntable, drum machine, sampler, synthesizer and human beat-boxing. [17]
- **Qawwali** is an art form with energetic musical performance of Sufi Muslim poetry that aims to lead its listeners to a state of religious ecstasy. "Traditional qawwali instruments are harmonium, sarangi, tabla, and dholak. Clapping, an important percussive component in qawwali music, serves as a rhythmic drone and is sustained throughout a song." [14]
- **Ghazal** is a common and popular form of music in the sub-continent with roots in classical Arab poetry [15]. It primarily consists of harmonium, santur, sarangi, sitar, tabla, and rabab [16].

III. Problem Statement and Objectives

As mentioned before, genre classification is usually done manually and sometimes it can be difficult to figure out the genre of a song this way, so building a deep learning model that classifies genres can prove to be very useful. In our study we aimed to address the following objectives:
1. Develop an appropriate dataset for this task.
2. Develop deep learning models for the classification task of music into appropriate genres, optimizing them to reach the highest possible accuracy.
3. Test the models and compare accuracies with pre-existing models.

IV. Related Work

Although this paper may very much be the first one that focuses on classifications of Urdu songs, there have been research papers and studies that have been done on the basis of music classification using Neural Networks. One such example is the research paper called *Genre Classification of Songs Using Neural Network*. Using Echonest libraries, the authors make use of a collection of attributes, including beats, tempo, energy, and loudness etc. that are acquired and input into the Parallel Multi-Layer Perceptron Network in order to classify two Hindi song genres namely Sufi and Classical. These were classified with an accuracy of the proposed scheme of roughly 85% [29].

Another related research paper called *Music Genre Classification Using 1D Convolution Neural Network* also makes use of Convolution Neural Networks. In this study, a brand-new dataset of 1000 traditional songs from Nigeria across seven genres was used. Seven low level characteristics, often referred to as content-based features, were retrieved from the songs in the dataset. The findings revealed that the systems accuracy level is 92.5%, with 92.7% precision [30]. These are some of the already few instances of studies done on native music classification. Thus, work related to Music Genre Classification shows that music information retrieval and classification is still an active research topic. There continues to be development in the field using new ideas yielding different results. The Classification models can be divided into two segments as in Figure 1

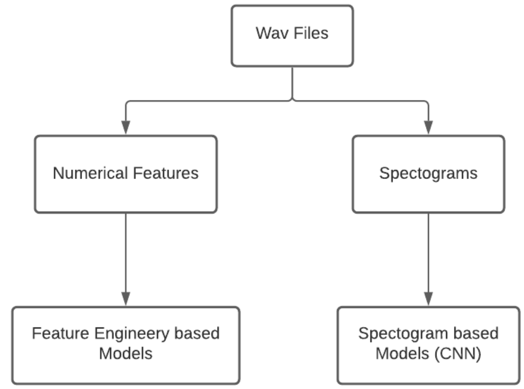

Fig. 1: Classification of Neural Networks

A. Models Based on Numerical Features

The **Detecting Music Genre Using Extreme Gradient Boosting** [3] paper predicts the genre of tracks provided in the FMA Dataset. They divided their approach into two parts, Numerical feature models and Image feature models, to provide a basis for comparison. Their first approach used Numerical features. Three different models were constructed. For the ExtraTrees and XGBoost classifier models they utilized a 5-fold cross validation to tune parameters, with n-estimators. Using Numerical features they also constructed a deep neural network with a random dropout (with p=0.5) at every dense layer. For the second approach a CNN was constructed which was trained on the spectrograms of the tracks. After every pooling layer, a random droupout (with p=0.5) was applied.

The result showed that traditional ensemble approaches outperformed the Neural Networks with XGBoost achieving the lowest lost, and CNN performing the worst with the highest loss, contradicting top tier approaches using neural networks for the same task. The study yielded a combination of fewer, smaller layers with decreased image size which resulted in the CNN's reduced performance.

In another research paper called **Single-labelled Music Genre Classification Using Content-Based Features** [6], the researchers analyzed features that could be correctly used to classify musical genre. After careful analysis of the features, the researchers eliminated those that did not show a strong correlation with the genre. Using these results they then used the GTZAN data set with 1000 tracks to train six off-the-shelf classifiers with 10-fold cross-validation, including Na¨ıve Bayes, Support Vector Machines, Multi-layer Perceptron, Linear Logistic Regression Models, KNearest Neighbours, and Random Forests. The results showed that the Linear Logistic Regression Model provides the best classification score of 81%.

B. Models Based on Spectrograms

In **Automatic musical pattern feature extraction using convolution neural network** [5], the researchers made an effort to understand the features that contribute to model for classification. The core purpose of their research was to understand the main features that mainly contributed to build the optimal model for Music Genre Classification. The dataset used for their approach was GTZAN consisting of 10 genres with 1000, 30 second tracks for each genre, sampling at 22050Hz at 16bits. Their results concluded that CNN had a strong capacity to capture informative features. The musical data had similar characteristics to image data, which require very less prior knowledge. As a result, the classifier accuracy was 84%. The resultant accuracy, according to the paper, could be enhanced further by "increased by parallel computing on different combination of genres." [8]

Furthermore, the researchers that worked on the research paper called **Improved Music Genre Classification with Convolutional Neural Networks** [7], used Short Time Fourier Transformation (STFT) magnitude spectrum, to visually represent the timbre texture of music. They made use of two different CNN architectures to formulate a comparative analysis between CNN and other forms of Neural Networks. The first CNN they used comprised of 10 layers, with 3 last layers were dense layers. Rectified Linear Units (ReLU) were used in all convolution and dense layers except for the top layer where instead, softmax was applied. The second Neural Network architecture was similar to the first one with the same number of layers and dense layers. The difference therein lay in the use of a residual layer and global max- and average pooling after the residual block, with shortcut connections. The architectures were trained on the GTZAN dataset using Batch Normalization to speed up the training process. The results showed that both Neural Networks performed exceptionally well with an accuracy of 84.8% and 87.4% respectively, showing that CNN's can be improved by combining max- and average pooling and using shortcut connections, inspired by residual learning.

Table I shows a summary of all the resulting accuracies achieved by previous models.

Model	Accuracy
NNET-2 [7]	87.4%
VGG-16 Fine Tuning [4]	64.0%
XGBoost [3]	78.0%
Linear Logistic Regression [6]	81.0%

TABLE I: Previous Research Models

V. DATASET

The Quality of data is very necessary to achieve good results. So, adequate and reliable data is paramount for accurate results.

The biggest hurdle that arose in the initiation of our study was finding an appropriate dataset for Urdu songs. This was very tough and due to lack of existing datasets, eventually it was decided to make our own dataset from scratch. The first task was to decide which genres to use, so we went with four most widely known genres of Urdu music: Ghazal, Qawwali, HipHop, Rock.

YouTube was used for downloading songs (songs uploaded by official YouTube channels were downloaded to ensure authenticity and integrity). Unlike the English music datasets that have been used in previous such projects, our Urdu dataset did have songs of variable lengths but uniformity was implemented on this data before processing it further. This will be discussed later in the paper. Table II illustrates details of our dataset, stating genres and the number of images in each category.

Genre	Count
Ghazal	250
Qawali	250
Hip-Hop	250
Rock	250

TABLE II: Details of Urdu dataset

Manual construction of dataset inevitably led to problems. Firstly, due to time constraints, the number of audio files downloaded were limited. The number of total songs that have been produced by the Pakistani music industry is deficient and is bounded in comparison to the amount of songs produced by the English music industry that has a global popularity. Another issue faced while building this dataset was that hardly any songs were genre classified. Since there is no unanimous agreement on the taxonomy of genres [2], only those songs were picked that are most widely accepted for each genre.

We embarked on a two-step approach to minimize problems such as biases and unreliability of classification. Firstly, some songs of the specified genres were identified using trusted platforms such as Gaana and the Spotify API. As each songs consists several elements of each genre such as rhythm, progression, and instruments were studied by listening to several songs from the same genre. This gave a basic pattern to identify. Next, to solidify the labelling created using the APIs all members of our research listened to each song in the dataset and unanimously decided on a genre for an initial rough idea. Any song that did not fit the general definition of the labelled genres was eliminated.

Now, for building a deep learning model, problems of having a small dataset still persisted. A major issue of a small dataset is over-fitting. Therefore, to overcome this Data Augmentation was implemented.

Data Augmentation forms new, different examples, using existing data, to train models. This alleviates the need for a larger dataset [12].

Thus, data augmentation was successfully administered in our dataset. This was done by taking several randomly chosen 30 second sections from the entire duration (always varied) of each song opposed to the conventional approach used by previous papers where only one 30 second interval is taken from each song. This increased the information taken from our dataset by many folds and lead to finer results as will be discussed later. For even better model training, the first 30 seconds of ghazals and qawwalis and first 20 seconds of rock songs were clipped before applying data augmentation. The reason for this was that music from all three of these genres in the beginning was very mellow, almost silent, which would have confused our model, leading to poor results. Our image dataset is available in our GitHub repository.

VI. Methodology

We first created a balanced dataset of Urdu music classified by genres. Then we trained and tested it on several models, such as CNN, XGBoost, and logistic regression, based on our research. Eventually, we narrowed it down to the method giving the best accuracies and further researched model variations in that domain.

As mentioned, the first task in the practical implementation of this research was to obtain MFCC images for the songs' .wav files using python's librosa library.

A. Mel Frequency Cepstral Co-efficient Generation:

Mel Frequency Cepstral Co-efficients (MFCC) gives us a 2D representation of the audio signals with time on the x-axis and values on the y-axis [4]. The following is a common way to calculate MFCCs:

1) Take (a windowed snippet of) a signal and perform the Fourier transform on it.
2) Using triangular overlapping panes, map the powers of the spectrum acquired above onto the mel scale.
3) Compute the logs of the powers at each mel frequency.
4) As if it were a signal, compute the discrete cosine transform of the list of mel log powers.

The amplitudes of the resulting spectrum are the MFCCs.

For our models, we used the MFCC spectogram with the following parameters:

1) Sampling rate (sr) = 22050 [5]
2) Frequency Scale: MFCC
3) n_mfcc = 32
4) Bins/Segments: 5
5) Sampling time: 30s.
6) Window Size: 1292x32.

Once all MFCCs were generated, the dataset was split randomly into training set (60%), validation set (20%), testing set (20%).

B. Convolution Neural Networks:

Convolution Neural Networks (CNN) are special Neural Networks that do in-depth feature engineering. Looking into the previous research, it was concluded that CNN is the best fit for our model, as it mostly gives the highest accuracy.

- **Pooling:** This method is essential as it not only ensures translation in-variance but greatly reduces the dimension of the feature map that is given as output by convolution.
- **Non-Linear Activation Function**: This adds enhanced feature extraction and retrieves more accurate predictions. ReLU function has been exercised in all models as it is quite reliable and avoids gradient vanishing.
- **Optimizers**: They minimize the loss function. For our models we have used Adam optimizer which is a default for most Neural Networks and gives optimum results. [19]
- **Model Saving**: Model Saving allows for the saving of the best possible model. During training, it may be possible to overshoot the lowest possible gradient using a specific learning rate. Model saving allows us to reload models for further evaluation or use. [20]
- **Batch Normalization**: It reduces internal co-variant shift, ensures correct weight initialization, does regularization (avoiding over-fitting), and makes the model less sensitive to hyper-parameter tuning. It also removes the need for dropout. [18]

VII. Evaluation Metrics

The evaluation of the performance of the models was executed using the following two metrics:

1. Accuracy: Literally speaking, this metric evaluates how accurate the model's prediction is in comparison to the true values. This can also be taken as the percentage of test data correctly classified.

2. Loss: It evaluates how well a model performs on the given data. In our models, we have used the Sparse Categorical Cross Entropy loss function. It takes labels as integers, calculates the cross entropy loss between the predictions and actual labels. Thus, one hot encoding is not required. [21]

VIII. Experiments & Results

We built several different models and experimented with them, narrowing our research down to the top three CNN models based on training accuracy. Then, these models were trained more rigorously with different parameters, and evaluated using the aforementioned metrics, to arrive at the best model.

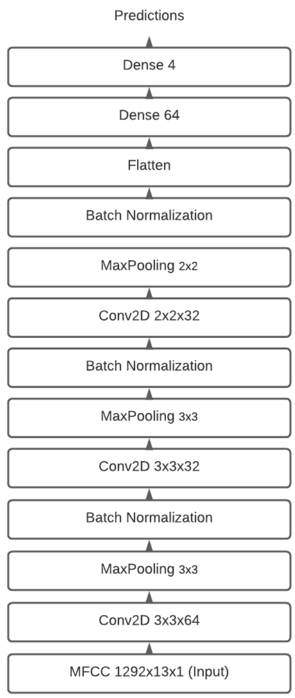

Fig. 2: CNN with Batch Normalization

A. Models

For our experiments, we implemented a vanilla VGG-16 Model using Keras with pre-trained weights on ”Imagenet”. Since VGG-16 was pre-trained the channels of the input layer could not be changed and required an RGB image with a minimum dimension of 32x32x3. To alleviate this problem we replicated out image into 3 dimensions essentially creating a gray-scale image, changing our dimension from 1292x32x1 to 1292x32x3 Though this implementation consumes a lot of memory, it could not be helped. Furthermore, The output of the VGG-16 was transferred into a flattening layer with RelU activation, and finally into a dense layer with softmax for classification.

1) CNN with Batch Normalization: This model follows a block approach. Each block has a convolution layer with ReLU activation followed by max pooling and then Batch Normalization. We have three such blocks in our network and a single dense layer finally applying softmax for classification. Figure 2 shows a visualization of this model’s architecture.

This model is based on the model NNET-2 presented in [7]. NNET-2 used a combination of convolution and dense layers, but what makes it stand out is the concatenation of the results of the first convolution layer with the results of the third. The network was inspired by the concept of residual learning proposed by He et al. [26]. The resulting model showed considerable accuracy as shown in Table I. However, CNN with Batch Normalization took a simplistic approach of deeper and narrower models [27]. Thus, the model consisted of convolutions layers with ReLU activation but also followed by Batch Normalization on every layer.

2) CNN with Global Average Pooling: For this model, the basic structure of 2 was made use of, but with added 1x1 Convolutions to control spacial depth and decrease the number of weights. These convolutions are followed by either 3x3 or 2x2 convolutions and has Batch Normalization employed. To decrease the number of parameters, the dense layers in the final layers are replaced with Global Average Pooling. This helps reduce training time and complexity of our model.

B. Results

Each of these models were run for our Urdu dataset for several thousand epochs until the validation accuracies became repetitive and reached a maximum. The model parameters were kept consistent throughout the models:

1) Learning Rate (lr) = 0.0001
2) Batch Size = 32
3) Epochs = 2000

The models with the best results are saved and the results on our dataset are illustrated in Table III.

Model	Accuracy	Loss
CNN with Batch Normalization	92.6%	0.0051
CNN with Global Average Pooling	83.1%	0.8079
VGG-16 with Transfer Learning	83.1%	0.0061
Linear Logistic Regression	82.7%	0.6514
XGBoost	81.8%	0.0359

TABLE III: Model results and evaluation

The results showed a clear conclusion. A simplistic model, consisting of Batch Normalization outperformed VGG-16 and other models achieving high validation accuracy and low loss. Both results conflict from [7] which used residual learning. However, for our Urdu Dataset result, it is important to acknowledge the limitations of our dataset as it is possible to get better and different results with a larger dataset.

To dive further into our best model (CNN with Batch Normalization), it was on testing data that had been separated before the start of our experiments. Figure 3 shows the results in the form of a confusion matrix. The results are quite promising. We see that our model gave a 100% test accuracy on the testing data for hiphop music and only one segment each was incorrectly predicted for the other three genres. This helps us understand the strengths and weaknesses of our model in terms of classification. Altogether, this gives quite a satisfying result. We tested our model further by making it predict genres on unseen data. Two songs for each genre, not included in the existing Urdu songs dataset, were accessed and acquired correct positive results.

IX. Conclusion & Future improvements

First, we successfully built a dataset of Urdu songs based on 4 genres. Then, MFCCs after some pre-processing of data

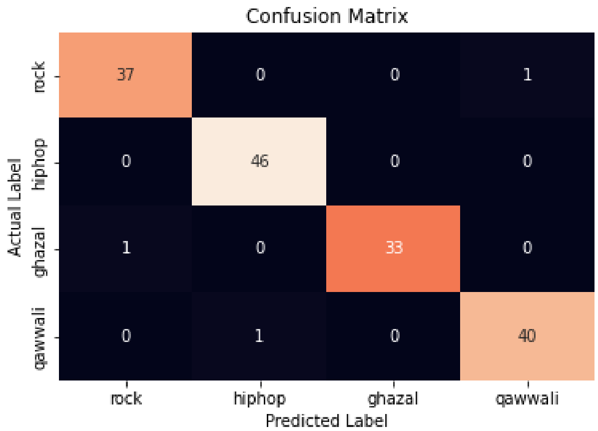

Fig. 3: Confusion matrix of Urdu test data

(including data augmentation) were found. Next, training of four different models were done on this data, keeping in mind the previous work done by people in music genre recognition and what was taught during our Introduction to Deep Learning course. A CNN model with Batch Normalization after each block and dense layers at the end proved to give us the highest validation accuracy.

Further improvements can be made to this classification problem. Firstly, this dataset was not very detailed nor large. So, the creation of a larger dataset with more genres will be helpful and will lead to better accuracy (for better model training) and better testing of this model. This means we can add more songs to each genre, as well as diversify the number of genres being used. In addition, Transfer learning can be implemented as it helps reduce learning times and increase accuracy of models as was apparent in [10], [11]. Furthermore, updating our model with Residual Learning, which has been shown to give considerable improvement in classification tasks [26] could also yield better results over a greater number of classes.

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