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# MUSICAL INSTRUMENTCLASSIFICATION USING MIRTOOLBOX

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**ABSTRACT:**

**In this paper, we propose the classification of instruments in continuous melody pieces or non-vocal sound pieces which may contain more kinds of instrument like flute in woodwind family, piano in keyboard, guitar in string, drum in percussion, trumpet in brass family.**

**The various sound of instrument is classified using MIR Toolbox which is music information retrieval toolbox. In this proposed system we use major features set like Tonality, Timber, Rhythm, Pitch, and Energy from MIR Toolbox useful for musical instrument. This system willextract the features of musical instrument, and use it for training and testing purpose. In testing phase, the sample is compared by using suitable machine learning algorithm KNN using Euclidean distance, and PNN using probability distribution function. The class of instrument is declared in the GUI. The performance of Instrument identification was checked using with different feature selection and ranking classifier. For the limited set of Musical Instrument types and samples, the system works satisfactory.**

**KEYWORDS: MIR Toolbox, KNN, PNN, Feature extraction, Timber, Tonality, Rhythm, Pitch, GUI.**

## I. INTRODUCTION:

Digital signal processing applications in the Sound, Music, and Voice these are very popular areas of research for applications field. In past four decades, MIR research is very useful in the area of Musical Instrument Identification, Singer Identification, Speaker Recognition, Music Melody Extraction, [1]

Classification of the musical instrument is most important application in the MIR Toolbox. The music instrument sound are available in different forms like monophonic, polyphonic, homophonic, etc. The monophonic sound consist only one instrument sound. The biphonic texture consists of two different instruments sounds played at the same time. In polyphonic sounds of different musical instruments are incorporate which are free from each other. The homophonic texture is in the western music. [2]

The proposed system works with the classification of musical instrument sound from a monophonic audio sample, where just single instrument is played at once. This musical instrument system produced some feature like as Timber, Tonality, Rhythm ,Pitch, Energy features are extracted from audio samples. In proposed framework we are working with three different classifiers namely K-Nearest Neighbor (KNN),Probabilistic neural network and k neural network to identify musical instrument. The purpose of proposed system is to achieve some objectives like: (A) identify musical instrument by extracting feature attributes from sound (B) Analyze feature extraction method and which classifier can gives better identification results.

In proposed system for feature extraction we use MIR Toolbox. MIR Toolbox consistsset of functions written in Matlab++. MIR toolbox is the software based toolbox the extraction of the audio files .This toolbox gives some strong method to extract variety of audio attributes characteristics from an audio file. These attributes are called as Audio Descriptor [3].

## II. LITERATURE SURVEY:

We studied different papers for instrument identification as well as feature extraction strategies.

Musical instrument identification using svm and formal concept analysis [S. Patil, T. Pattewar] this paper propose system By using classifier and formal concept analysis. This system can be less dependent on human supervision. Musical instrument can be classified using SVM as well as MLP classifier and analysis result of SVM classifier is greater than MLP classifier. [4].

A novel technique suggested by [Dr. D. S. Bormane] for the classification of musical instrument based on wavelet packet transform. This technique represents global information bycomputing wavelet coefficients at different frequency sub bands with different resolutions. Music instrument classification Accuracy has been significantly improved Utilizing wavelet packet transform (WPT) alongside advanced machine learning method. [5]

Instrument classification in polyphonic music using timber analysis [Tong Zhang] presented technique for classification purpose. In this system a sound signal piece is segmented into notes by detecting note onsets. All Features are computed for each note separately, including temporal features, spectral features and partial features. A feature vector is then framed for each note which is to be sent to the classifier. A set of classification tools are used toclassify onenote to one kind of instrument.[6].

Musical Instrument Classification utilizing Higher Order Spectra[Bhalke D. G; Rama Rao C.B; Bormane D.S**]** This paper presents classification and recognition of instrument sounds using higher order spectra include that Bispectrum and Trispectrum. Higher order spectra based features increase the recognition accuracy, Musical instrument classification and recognition has been implemented using Higher Order Spectra and other conventional features using Self Organizing Map supervised neural network. The main reason for improved result is due to its high signal to noise ratio (SNR), elimination of Gaussian noise, and HOS has the ability to differentiate various non-Gaussian signals for more accurate identification.

## III. PROPOSED METHODOLOGY:

The proposed system block diagram is shown in Fig.1 consist of three stage i) Preprocessing of musical instrument ii) feature extraction iii)classification using KNN,PNN and K neural network.

In the first step, which is single sound is given as an input to a system. The database is arrangedfor training and testing purpose, which contains all sound samples of the five musical instrument that is flute, Guitar, Piano, Drum, Trumpet. In the Preprocessing stage first of all remove the silence part and noisein the music signal using zero crossing detection rate. After preprocessing the sound input stored in the audio sample database and stored sample given to the feature extraction unit using MIR Toolbox. This feature extraction unit various feature are extracted that is timber related feature, tonality , rhythm , pitch , energy , statistics . Feature extraction value is evaluated and given to the classifier phase and for further classification purpose.

The proposed system works in two phases, (i) training phase (ii) testing phase, known sound samples are given as input to system is called training phase. In training phase we use 10 sound sample for training purpose .In testing phase unknown sound sample are given as input to the system. In Testing phase store 5 sound sample for testing purpose. In last step, all extracted feature vector value stored in database and compare training and testing value and classified instrument using K-Nearest Neighbors (K-NN), probabilistic neural network and k neural network classifier.

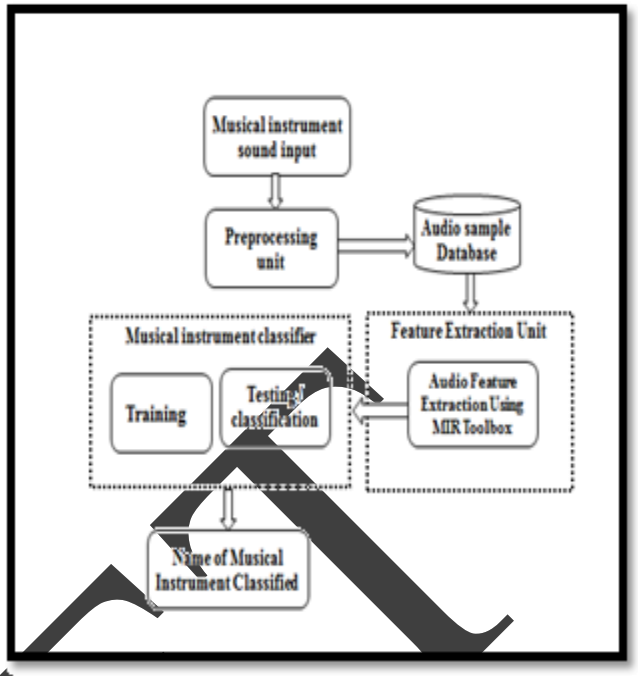


Fig 1. Block diagram of proposed system.

## IV. FEATURE EXTRACTION:

### A] TIMBER RELATED FEATURE:

### 1. ZERO CROSSING RATE(ZCR):

Present noise in the music sound signal is removed using the Zero Crossing Rate (ZCR) and also used in voice activity detection (VAD) finding human speech is available in sound section or not. ZCR is defined the many times the audio sound signal changes its sign from positive to negative and negative to positive in window. If the zero crossing rate is smaller when the sound flag has less number of sign. For the noisy sound present in the signal when the sound signal has multiple time sign changes, then Zero

Crossing Rate (ZCR) calculated will be high. ZCR used as a simple indicator of noisiness. [9]

$$Z_t = \frac{1}{2}\sum_{n=1}^{N} |\text{sign}(x[n] - \text{sign}(x[n-1])|$$

### 2. BRIGHTNESS:

Brightness is also called as high frequency energy and It's nature same as roll off. In that cut off frequency is fixed first and above that cut off frequency it is minimum frequency value and measuring the amount of high frequency energy in that minimum frequency value. The value of brightness is always in between 0 to 1.[9]

### 3. MFCC:

MFCC means Mel-Frequency Cepstral Coefficients are also based on the STFT. Taking the log-amplitude of the magnitude spectrum, the FFT bins are grouped together and smoothed according to the motivated Mel-frequency scaling. Finally, resulting feature vectors a discrete cosine transform is performed.

**4. ROLL OFF:**

Measure amount of high frequency energy in the sound signal by usingRoll off. It is calculated by finding the frequency in the certain fraction of total energy is always contained below that frequency. The ratio of total energy is 0.85 by default. Roll off is the frequency below 85% of the amplitude distribution. Roll off is measures the spectral shape.

$$\sum_{n=0}^{M} M(n) = 0.85 \times \sum_{n=0}^{M} M(n)$$

Where M (n) is the magnitude of the Fourier transform at frame tandfrequency bin.

**5. REGULARITY:**

Regularity is the degree of variation of the sequential peaks of the spectrum. It is sum of square of the difference between amplitudes of neighboring partials.

$$(\sum_{k=1}^{N}(a_K - a_{k+1})^2) / \sum_{K=1}^{N} a^2k$$

There is another approach to find the Regularity. It is calculated as the sum of amplitude minus mean of previous, same and next amplitude.

$$\sum_{K=2}^{N-1} \left| a_k - \frac{a_{k-1} + a_k + a_{k+1}}{3} \right|$$

The audio signals, which are inputted to system are of fixed duration and contain continuous amplitude throughout the signal. Hence, there is not much significance in considering the attack time or attack slope for feature extraction in our research[10]

**B] STATISTIC:**

**1. CENTROID:**

Centroidmoments use in statistics and obtained distribution shape. The first moment of centroid, is called as mean, it's geometric center (centroid) of the distribution and is a measure of centroid for the random variable. [8]

$$\mu 1 = \int xf(x)dx$$

**C] TONALITY:**

**1. CHROMOGRAM:**

Chromogram is also called as Harmonic pitch class profile. Chromogram shows distribution of energy along the pitches or pitch classes. By applying log frequency transformation then spectrum is converted from the frequency domain to the pitch domain. The distribution of the energy alongside the pitches is called the Chromagram. [3]

**D] RHYTHM:**

Rhythmic features class is characterize the movement of music signals some time and contain some information such as the regularity of the rhythm, beat, tempo, and the time signature. Rhythm define the characteristic of the sound signal because they follow a particular pattern. These features are rhythmical structure and beat strength. For better classification purposes it is more interesting to extract information about these features. The feature of rhythm representing rhythm structure is based on detecting the most salient periodicities of the signal and it is usually extracted from beat histogram

**E] PITCH:**

The frequency of a sound wave is what ears understand as pitch. A higher frequency sound has a higher pitch and a lower frequency sound has a lower pitch. The pitch frequency can be calculated by using auto correlation method in the tool box. The pitch periods of a given music document is computed by finding the time slack corresponds to the second biggest top from the central peak of autocorrelation arrangement. Then pitch frequency is estimated from the pitch periods.[11]

**F] ENERGY**

**1. ROOT-MEAN-SQUARE ENERGY (R.M.S):**

Root-Mean-Square is used to measure the power of a signal over a window. The global energy of a signal can be computed by taking the root average of the square of the amplitude (RMS)

$$x_{RMS} = \sqrt{\frac{1}{n}\sum_{i=1}^{n} x_i^2} = \sqrt{\frac{x_1^2 + x_2^2 + \cdots + x_n^2}{n}}$$

**2 .ROUGHNESS:**

Roughness, is, also known as sensory dissonance. Whenever a pair of sinusoids is close in frequency that time occurs beating phenomenon, It is related to the roughness. Estimation of sensory dissonance depending on the frequency ratio of each pair of sinusoids.

**V .CLASSIFIER:**

In propose method use of two techniques for classification of musical instrument.

A. K Nearest Neighbors
B. Probabilistic Neural Network

**A] KNN**:

KNN means K-nearest neighbours classification technique its robust method has been applied in various musical analysis problems. KNN is non parametric lazy learning algorithm for classification and regression purpose and it is one of the simplest method. KNN is stores all available cases and classifies new cases based on similarity function called as distance function. A

distance measure is calculated between all the points in a dataset using Euclidean distance. According to these distances. A distance matrix is constructed between all the possible pairings of points in dataset.

In the first stage, the algorithm computes the distance, d(**x**, **VI**), between **x** and each feature vector, **VI**= 1…. M, of the training set, where M is the total number of training samples. The most common choice of distance measure is the Euclidean distance, which is calculated.

$$d(x, vi) = \sqrt{\sum_{J=1}^{D} (X(J) - VI(J))}$$

Where Dis the dimensionalityof the feature vector. After d(**x**, **v**i) has been computed for each **v**i. [10] [12]

**B] PNN:**

PNN is called as probabilistic neural network which is feed forward neural network, and most useful in classification and pattern recognition purpose.In PNN algorithm, the probability distribution function (PDF) of each class is approximated by utilizing a Parzen window and a non-parametric function. Then, utilizing PDF of each class, the class probability of a new input data is estimated and Bayes' rule is then employed to allocate the class along with top most posterior probability to new input data. By this method, the probability of mis-classification is minimized. In the PNN there four layers are used for classification purpose in that input layer, pattern layer, summation layer, output layer. Input layer consist of multiple neurons represents a predictor variable. All Categorical variables are usedN-1 neurons when there are N number of categories or classes. Input neuron standardizes the values by subtracting the median and dividing by the inter quartile range. Then the input neurons feed the values to each of the neurons in the hidden layer.

Second layer is pattern layer consist one neuron for each case in the training data set. In training data set, stores the values of the predictor variables for the case along with the target value. A hidden neuron use the Euclidean distance of the test case from the neuron's center point and then applies the radial basis function kernel function using the sigma values. Third layer is the summation layer in this layer there is one pattern neuron for each category of the target variable. The actual target category of each training case is stored with each hidden neuron; the weighted value coming out of a hidden neuron is fed only to the pattern neuron that corresponds to the hidden neuron's category. The pattern neurons add the values for the class they represent**.** The output layer compares the weighted votes for each target category accumulated in the pattern layer and uses the largest vote to predict the target category.

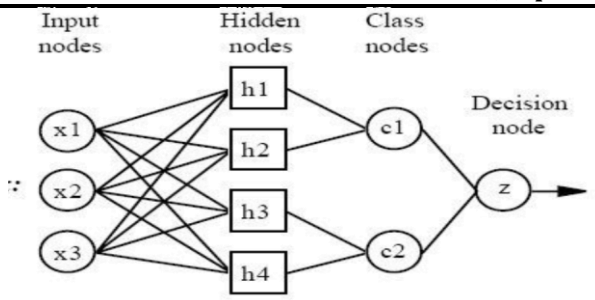


FIG 2 .Architecture of PNN

## V. RESULTS AND DISCUSSIONS:


FIG 2.GRAPHICAL USER INTERFACE

| I/P | FEATURES | | | | | | CLASSIFIER |
|---|---|---|---|---|---|---|---|
| | F2 | F3 | F4 | F6 | F7 | F8 | KNN/PNN |
| Tone 1 | 18125 | 0.341 | 0.201 | 6.92 | 0.008 | 1090 | FLUTE |
| Tone 2 | 3720 | 0.716 | 0.440 | 6.27 | 0.721 | 2055 | DRUM |
| Tone 3 | 7859 | 0.721 | 0.647 | 9.61 | 4.720 | 3802 | GUITAR |
| Tone 4 | 1582 | 1.067 | 0.200 | 4.38 | 0.008 | 1011 | PIANO |
| Tone 5 | 3807 | 0.889 | 0.464 | 1.42 | 0.006 | 1947 | TRUMPET |

Input file: Unknown tone(.WAV/.MP3) Extracted Feature values and classified

The proposed system was implemented in MATLAB with MIR Toolbox This toolbox is widely used for musical feature extraction .The system has been tested using five musical instrument which are Flute, Piano, Drum, Guitar, Trumpet .The GUI is displayed in Fig. In GUI first select the musical instrument tune in database and all feature extracted using feature extraction method and result will be displayed on GUI .Using this feature extraction value classification of the musical instrument using KNN ,PNN classifier classified which musical instrument was played and classified result displayed on GUI.

## VI. CONCLUSION:

The proposed system deals with the classification of musical instrument from instrument tune. In this system music related feature are extracted. Timber, Tonality, Rhythm, Pitch, Statistic, Energy these feature value extracted using Mir toolbox.. We use feature extraction value for classification of musical instrument using KNN, PNN.

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