2015 1st International Conference on Next Generation Computing Technologies (NGCT-2015)
Dehradun, India, 4-5 September 2015

Indian Instrumental Music: Raga Analysis and Classification

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***Abstract*—Raga played by Indian instrument is the actually soul of the Indian classical music. Indian classical music is famous around all over the world for its particular structure and well soundness. Our work is related to analyze and classify the instrumental music according to their features. This will help to non-professional and music learner for understanding and acquire knowledge about the music using the system intelligence. There are various features for analysis of music but our approach is towards the spectral and temporal features. For extraction of feature we take spectrum, chromagram, centroid, lower energy, roll off, histogram etc . At very first we just collect clips of ragas and find out the spectral and temporal features. These features show the better result. We are using four ragas namely:- Bhairav, Bhairavi, Todi and Yaman. For classification we use different types of classifier just like KNN classifier and SVM classifier they gives approximate 87% and 92% accuracy respectively.**

Keywords- North Indian classical music, Spectral property, temporal property, KNN, SVM

I. INTRODUCTION

Indian classical music is known for its perfect technical soundness and well defined structure known as ragas . Each raga is based on some specific combination of swara(notes). Any raga should have at least five notes out of seven and it is also possible that two raga has same notes but the aarohan, avrohan and pakad is different so one can identify it properly. Expert person can understand the raga very easily, but for learner it is very difficult to classify and identify the raga. So this method is helpful for both professional and non-professional one. Proposed work is related to classification and analysis of Instrumental Indian classical music. We are using MATLAB tool for processing music segment and find out information related to raga analysis and classification.

Music Information Retrieval toolbox (MIR)[2] is also helpful to find out the features for comparison. This software widely use in western music and now days implemented in Indian Classical music. Work focused on four ragas namely Bhairav, Bhairavi, Todi and Yaman and the selected instrumental music is mixed polyphonic to find out the spectral and temporal features like brightness, RMS energy, spectral flux spectrum chromogram, histogram etc. For classification we preferred KNN and SVM classifier [2], [3].

Swaras are the frequency generated by instrumentally or vocally. Actually these seven swaras represents the absolute frequencies ratio with respect to each other and these are very similar to SOLFEGE in western music The seven swaras are namely: Shadja (Sa), Rishabh (Re), Gandhara (Ga), Madhyama (Ma), Panchama (Pa), Dhaivata(Dh), and Nishad (Ni).Out of seven, two swaras i.e Sa and Pa has only pure form while other five has both pure and impure form in structural elements of raga. The purpose behind this work is to design a computer based education of Indian classical music for everyone. Following are the basic terms related to Indian classical music.

Raga: Indian music is famous for its ragas specialty. Raga represents the color of emotion and it has some specific melodic phrases. Raga has definite pattern of notes (swaras). Two ragas may be same notes but the pattern of distribution is different in case of each raga that is why two ragas have same notes but they tuned differently.

Aarohan ,Avrohan and Pakad: Aarohan and Avrohan is the ascending and descending progression of swaras respectively. Pakad is a small sequence of swaras in a raga that acts as a mark for the raga and an artist often calls and recalls the pakad over a performance.

Vadi , Samvadi and Jati: The Vadi is the most noticeable notes used in a raga and next to vadi, samvadi is the second most noticeable notes in a raga. Often Vadi as the Monarch of swaras for that raga. There are three jati in Indian classical music namely: Audhav-has five notes, Shadav-has six notes and Sampoorna has seven notes. Ragas have combination of Jati, e.g. Audhav- Audhav, Audhav Shadav.

Proposed work deals about both spectral and temporal properties of the ragas while existing works either dealed with spectral or temporal properties at one time. Flow of proposed work start from data base generation and end with classification and end result.

The rest of the paper is organized as follows: The literature survey is described in section II. Methodology explained in section III. The experimentation and results are projected in section IV. Section V includes conclusion and future work.

II. LITERATURE SURVEY

For literature we have been following the related papers for, how we can extract these features the method of analysis and classification of ragas, to distinguish the different characteristics of raga and their structure and methodology. Pranay Dighe et.al [1] has proposed work to vigorous programmed analysis of Indian classical music through machine learning and signal processing toolbox like MIR toolbox. They developed idea to perform scale-independent raga identification by using a random forest classifier on swara

histograms and succeeded state-of-the-art results for the same. The average accuracy is approximate 97% and some algorithm is also used by them especially for computation of swara based features. By referring this paper we acknowledged about the features extraction of ragas and using these features for the classification of two ragas. Although this paper has done good work in classification of ragas but no means for temporal properties of ragas have been provided by the authorss. The same has been included in proposed work.

Gopala Krishna Kaluti and Rajeshwari Shreedhar et.al[2][3] has proposed and music recognition and classification their work related to implement computational model for raga recognition. In this work they examined the raga and identifying these ragas naturally. They mainly focus on the pitch of the notes and through which it is recognizable of notes .The maximum accuracy is approximate 94%. Through this paper we acquire knowledge about we can implement this technique for both western music and Indian classical music. Although this paper has done excellent work in raga identification and classification but no any description about the analysis of features of ragas have been done by the authors.

Sourabh Deshmukh et.al [3] has proposed ethno musico logical identification of singer and ragas. He has used features for analysis and all those features are analysed in time or frequency domain and for classification he has used various types of classifier and maximum accuracy is 93%. V. Sivaranjani [4] has proposed work for mainly pitch analysis and retrieves information of music which is related to pitch. Soubhik Chakraborty et.al [5] has proposed work related to scientifically verify a raga on the basis of vadi and samvadi. They have done statistical analysis of ragas and not using properties like temporal or spectral which are used by proposed work.

Prasad Reddy et.al [6] suggested Automatic Raaga Identification System for Carnatic Music mainly for melkartha raga identification. They have used Hidden Markov Model and also introduce special algorithm for pakad matching for this purpose Michael K.[7] has recommended exploration for North Indian classical music, his process is related to analysis of the raga in north Indian classification the north Indian classical music. He used ethno musicological method for raga analysis and positing it. Kris West [9] worked on the analysis of audio music using multiple processes for classification and implemented so called search by example method. He used novel machine learning algorithm (MVCART) that is totally based on the classic Decision Tree algorithm.

Preeti Rao et.al [10] proposed identification of melodic motifs in raga. They used machine learning method for phrase classification on data that is manually segmented. They used HMM and Dynamic time warping method for classification. Rajshri Pendekar et.al [11] worked on raga and swara identification using harmonium, they used onset detection for determination of spectral flux for frequency estimation. The programing used here is dynamic in nature this technique is mainly used for template matchinghey used NN classifier for classification.

Although all the papers which we referred here for literature survey is related to music but there are very few work has been done in Indian instrumental music, our proposed work is useful for music learner, professional and non-professional people while existing works are not useful for everyone. This work deals about both spectral and temporal properties of the ragas while existing works either dealed with spectral or temporal properties at same time. Through this method we can also analysis and identification at the same time.

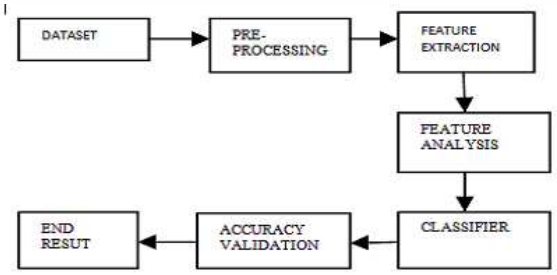

Fig. 1. Block diagram of methodology

III. METODOLOGY

A. DATA BASE

The steps followed in proposed methodology are shown in fig.1.

Data base collected from live concerts recording, original-CDs and download from internet. We have selected four below.

B. PRE- PROCESSING

Preprocessing is the second step of methodology, in this step we take all the ragas and first converts these files into .WAV files. After conversion we cut each file into a specific duration i.e approximates 60sec so that we can get information about each and every note properly. For these purpose we use Virtual Dj Pro software. After pre processing we fed the data into feature extraction.

C. FEATURE EXTRACTION AND ANALYSIS

Here we mainly focused on temporal as well as spectral properties of raga wave file, because these properties are provides good result in classification of ragas.

D. ONSET

For onset detection we use spectral flux method for ragas, in this method we calculated change in spectral energy from one frame to the next frame by using spectral flux. Actually spectral flux is the squared of normalized difference between consecutive spectral distribution.

$$\sum_{k=0}^{1} = (|X\_n(k)| - |X\_(n-1)(k)|)^2 \quad (1)$$

where n-1 and n are the frame indices and (k) is the FFT of nth frame. So through Onset detection we can easily find out the energy distribution of the specific notes.

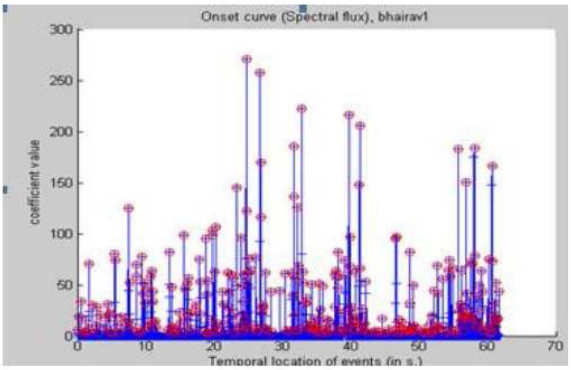

Fig. 2. Onset curve of raga bhairav

E. ZERO CROSSING RATE

Zero crossing indicates the changing of sign of a signal from negative to positive or vice versa. It indicates frequency of signal amplitude time change. This property used for music information retrieval and recognition of music too.

$$ZCR = \sum_{n=1}^{N} \frac{sgnx(n) - signx(n-1)}{2N} \qquad (2)$$

Where sgn[]and x(m) is a signum function discrete audio Where sgn[]and x(m) is a signum function discrete audio respectively.

F. CHROMAGRAM

Chromagram denotes the distributions of energy along pitches. There are 12 semitones in western music which is equivalent to notes of Hindustani classical music. These semitones octaves are C, C, D, D, E, F, F, G, G, A, A and B. these semitones are fixed with absolute frequency value and most interesting thing is that musical octave has a special property is that the current semitone is equivalent to one octave below or above to it so semitone has the property of repeatability it repeats in each octave above and below. By the table which is given below we can relate the semitones of western music with notes of Indian classical music. Although chromagram is find out through MIR toolbox but sometimes this is not provides exact notation of swara.

Chromagram is useful for extraction of notes of ragas. By the help of above diagram we can identify the notes which is used in raga bhairav.

G. PITCH DETECTION

Pitch detection is processed for the finding the frequency of pitch. It plays important role because it is linked with periodicity of the audio wave signal and these periodic signal are made up of fundamental repeated frequencies, these fundamental repeated frequencies are multiples of a joint fundamental frequency. There are various approaches for finding the pitch of the audio wave namely: spatial domain, time domain frequency domain. Here we apply MIR toolbox to find out the pitch of the signal.

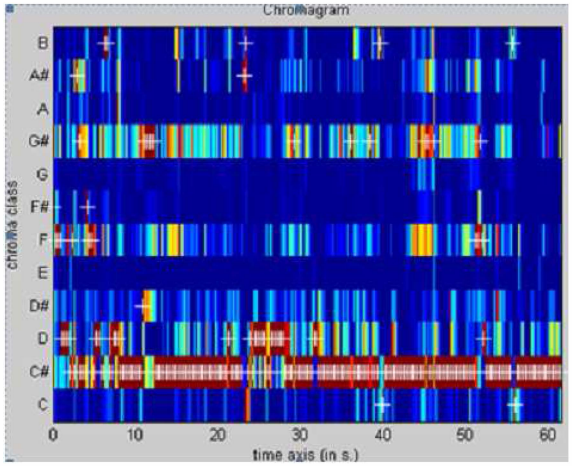

Fig. 3. Distribution of chroma on the notes of the raga

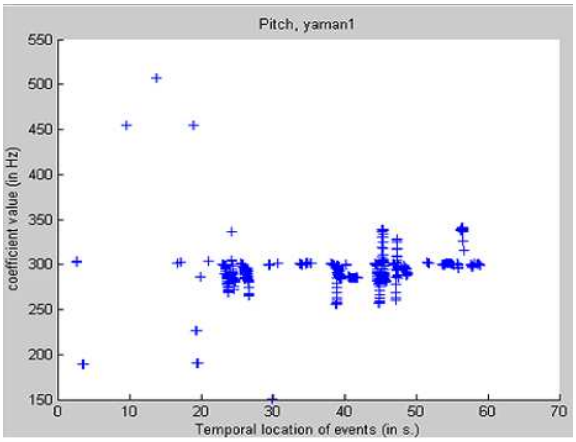

Fig. 4. Pitch detection of raga Yaman

H. LOWER ENERGY

Lower energy is the percentage of frames showing a RMS energy that is lower than a given threshold. For instance, for a musical excerpt with some very loud frames and lots of silent frames, we would get a high low-energy rate.We take lower energy in our proposed work to find out the loud and silent frames, it provides the easy way to detect the notes and also energy of specific notes.

I. CENTROID

Centroid is the center of gravity of the spectrum

$$C = \sum_{k=1}^{N/2} M \frac{F((k) * X(k)}{/} \sum_{k=1}^{N/2} x(k) \qquad (3)$$

where f [k] is the frequency at bin k, and x(k) represents weighted frequency value or magnitude. Centroid is used to characterize a spectrum, it also indicates that where is center of mass of the is present

J. ROLL OFF

The roll-off is defined as the in the term of frequency a frequency lower than 85% of the magnitude distribution of

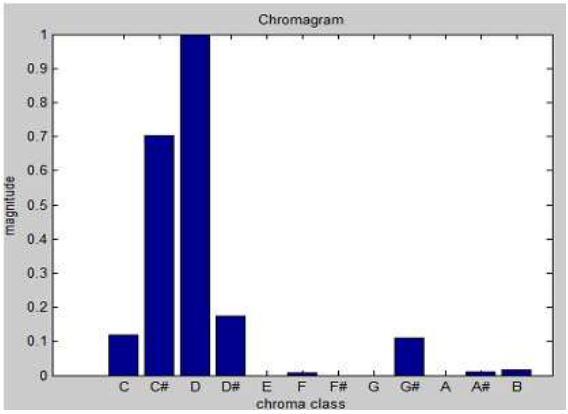

Fig. 5. Chromagram of Raga Bhairav

TABLE I. COMPARISON BETWEEN OBSERVED AND ACTUAL NOTES

Notes	Observed	Actual
Vadi	Dha(k)	Dha(komal)
Samvadi	Re(k)	Re(komal)

TABLE II. ANALYSIS BETWEEN OBSERVED AND ACTUAL VALUE

Notes	Observed	Actual
Vadi	Dha(k)	Ma
Samvadi	Sa	Sa

TABLE III. CLASSIFICATION OF RAGA WITH VADI AND SAMADI

Raga	Test sample	Accurately classify	accuracy
Bhairav	15	12	80%
Bhairavi	10	8	80%
Todi	15	10	67%
Yaman	16	12	75%
total	56	42	75%

TABLE IV. RAGA CLASSIFICATION ACCURACY WITH DIFFERENT CLASSIFIER

Classifier	Accuracy
SVM	92%
K-NN	87%

the spectrum is concentrated. Alike the centroid, it is also a measure of spectral shape and high value of frequencies. Therefore it can be said that there exists a strong correlation between both the features. The equation for rolloff is

$$\sum_{k=1}^{M} x(k) = 0.85 \sum_{k=1}^{N/2} x(k) \tag{4}$$

If M is the largest value of k for which this equation is satisfied then this frequency M is the roll-off, the value of M is changes according to the raga.

K. CLASSIFICATION

For classification of ragas we are using KNN and SVM respectively. We depicted each classification in detail given below.

K-NEAREST NEIGHBOR (KNN) : This method is used for pattern recognition and classification. Here some steps by which we apply this classifier for raga classification

Take feature vector of both test and train ragas. Now compare the features of both test and trained ragas. Find the Euclidean distance between test vector and trained vector of ragas The test segment assigned only those who have most common category among k nearest. KNN-classification can be classified by following equation

$$C* = \sum_{i} {}_1(c, (f(x))) \tag{5}$$

where c is the class level i.e raga identity and $fi(x)$ is the class label for the ith neighbor of x and *(c, fi(x))*. This method gives 87% accuracy.

SUPPORT VECTOR MACHINE(SVM): SVM is supervised learning method and it is used for classification. This method is used for data analysis and classification. In this method we categories data into two classes. SVM classifies data by finding the best hyper plane that separates all data into two classes. SVM gives approximate 93% accuraccy

IV. EXPERIMENTAL RESULT

We are using four ragas for our experiment and we find the final result of our work with accuracy 87.5% and 93% respectively. Here we used KNN and SVM classifier for classification approach. Through all the properties we have used here are give better result in classification also .Although we are using KNN and SVM classifier, graphically it seems easy to classify the Indian classical music.We are taking some spectral properties of raga for analysis and we can find out the true and wrong raga. Let us see with comparison between observation and actual ragas.We get fundamental frequency of the different raga by using this methology which is also play an important role in classification of raga.

Comparison between actual and observe notes of raga bhairav and bhairavi using chromagram

Histogram Result: Through histogram graph here we can find out the Vadi and Samvadi notes and by the help of graph and using the value of vadi and samvadi it is while easy to detect the raga, we can also find out which type of raga has been played through this process

The highest bar shows the value of Vadi and nex to Vadi is Samvadi. We know that the value of vadi is highest among all notes. Now from above fig it is cleared that the value of vadi is approximate 2.25 which is nearly to raga yaman.

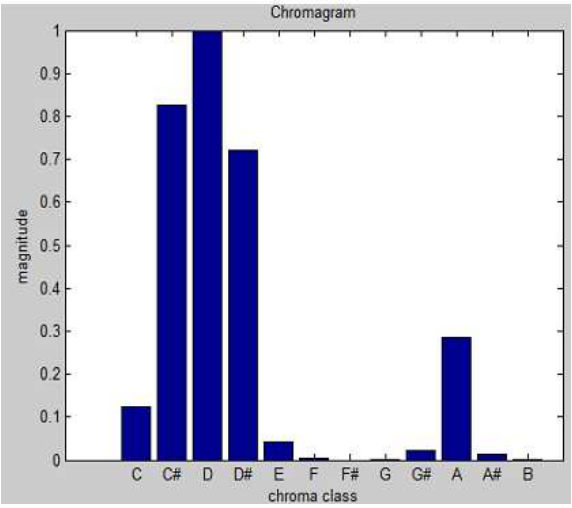

Fig. 6. Chromagram of Bhairav

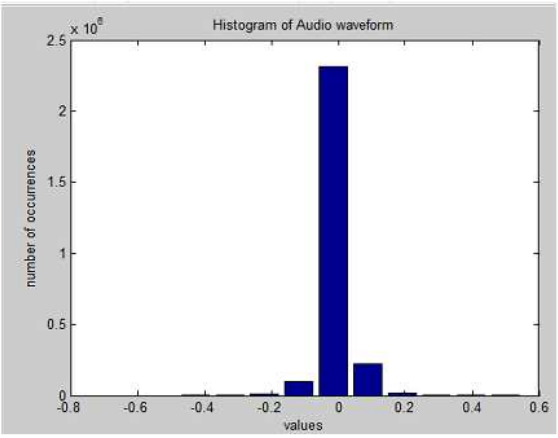

Fig. 7. Histogram of raga Yaman

V. CONCLUSION AND FUTURE WORK

In the proposed work, an acoustic and signal processing based approach is used for analysis and classification of Indian instrumental music. We have tested our algorithm over the database of 60 wave files. Our work is concerned with the discrimination between four different raga using KNN and SVM classifier.

Through this work we are emphasized the spectral and temporal properties of instrumental raga .The KNN classifier can significantly support in classification of different ragas with an average accuracy as high. Although this work has done for analysis and classification but we can also use this methodology for detection of raga also. This classification provide approximate 87.5% accuracy.

The main purpose behind this proposed work is designed to a model for music learner and music lover by the help of this method a person can easily classify the difference between two different ragas. This technique is also very helpful in music recommendation system. However it is also helpful in music synthesis and invention of new raga. Automatic tagging is also possible through this work.

Future work also lies to improve the dataset uses as maximum as possible and short out all the imperfections which could not improve through this proposed work to increase the accuracy.

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