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Machine Learning Approaches for Mood Identification in Raga: Survey

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Abstract- Music is a "language of emotion", which defines the emotion or feeling through music. Music directly connects to the soul and induces emotion in mind and brains. In Hindustani Classical Music raga plays very important role. It defines characteristics that differentiate ragas uniquely. Hindustani Classical Music also has nine different swaras that specifically define the emotion. In this paper we surveyed different techniques for raga identification and differentiate them according to their work and accuracy. We give the rasa - bhava relationship and raga-rasa mapping that defines the emotion related to raga.

Keywords – Indian Classical Music, Emotion, Raga- Rasa relation, Classifiers.

I. INTRODUCTION

Indian classical music:

One of an ancient tradition is Indian classical music that is an art form that is continuously growing. It has its roots in Sam Veda. Indian classical music is divided into two branches: Carnatic (South Indian Classical Music) and Hindustani (North Indian Classical Music). Carnatic music is sharp and involves many rhythmic and tonal complexities. Hindustani is mellifluous and meant to be entertainment and pleasure oriented music.
Indian classical music and Western music vary from each other with respect to their notes, timings and different characteristics associated with raga. Swaras of Indian classical music are similar to the note of western classical music. There are many characteristics of Hindustani classical music. One of them is Raga that plays a vital role in an Indian classical music. Raga is a collection of different unique notes that are having some special properties like Arohana, Avarohana, pakad, tal etc. Raga is divided into two-system Hindustani (North Indian) music, Carnatic (South Indian) music. Indian music has seven basic swaras (notes) namely Sa, Ri, Ga, Ma, Pa, Dha, Ni (*Shadja, Rishab, Gandhar, Madhyam, Pancham, Dhaivatand, Nishad*. Following are some components of Indian Classical music [9]:

Tonal Components of Hindustani Art Music:

- Naad: It is to irregular vibrations, which would be heard as noise a series of regular vibrations in a medium like air (as opposed). The frequency of vibration concludes the pitch of sound it represents, which ranges from 20 Hz to 20,000 Hz suitable to human ear.
- Swara (Note): Swara is a Sanskrit word that is a note in the octave. The seven basic swaras of the scale are named shadaj, rishabh, gandhar, madhyam, pancham, dhaivat and nishad, and are shortened to Sa, Ri (Carnatic) or Re (Hindustani), Ga, Ma, Pa, Dha, and Ni and they are written as S, R, G, M, P, D, N. Generally, these notes are known as the Sargam.
- Shruti (Microtone): Shruti in Indian Classical Music is a musical pitch. Fundamentally, it is a note from which all others are derived. This word is derived from the root "Shru" (to hear) and its original meaning is any sound that can be clearly heard by the ear. There are twenty-two shrutis; Tivra, Kumudwati, Manda, Dayabati, Raktika, Raudri, Krodhi, Bajrika, Prasarini, Priti, Chandobati, Manjari, Kshiti, Rakta, Sandi-pini, Alapini, Madanti, Rohini, Ranjani, Ramya, Ugra and Kshovini.

These swara, naad and shrutis are root of Indian classical music. Each of them contributes to specific emotions. Indian classical music has deep relation with human emotions [12].

Melodic Structures in Hindustani Art Music:

- Thaat (Mode): There are 10 thaats in north Indian classical music. Those are Asawari, Bilawal, Bhairavi, Bhairav, Kafi, Khamaj, Marwa, Kalyan, Purvi and Todi [12].

- Raga (Scale): Raga is the backbone of Indian classical music. The raga word comes from Sanskrit word "Ranj" which means to make happy, delight and satisfy. Raga can produce various or different moods like shanta, raudra, bhakti, shringara etc which are nothing but Rasa in Indian classical music [12].

- Rasa (Aesthetic delight): In Indian aesthetics, a rasa denotes a vital mental state and is the eminent emotional theme of a work of art. Each rasa describes unique human emotion. Each raga in Indian lassical music is associated with one or more rasa. There are nine rasas in Indian classical music: 1) Shringar (Love), 2) Hasya (Humor), 3) Karuna(Pathos), 4) Rudra (Anger), 5) Veer (Heroism), 6) Bhayanaka (Terror), 7) Veebhatsa (Disgust), 8) Adbhuta (Wonder), 9) Shanta (Calm) [12].

II. MACHINE LEARNING APPROACHES

Machine learning is the field, which provides computers the ability to learn without being certainly programmed. Machine learning discovers the study and construction of an algorithm that can learn from and make predictions on data. Machine learning is related to computational statistics, which also focuses in prediction making by computers. Sometimes Machine learning is consolidated with data mining, where the latter subfield focuses more on experimental data analysis and is known as unsupervised learning. There are different approaches of machine learning like artificial neural network, decision tree learning, association rule learning, support vector machines, clustering, Bayesian network, Hidden Markov model, K-NN. These approaches give different accuracy results depending on the input [13].

III. RELATED WORK

There is no rule or any defined procedure for raga identification; usually there are some measures by which people can detect any raga from any musical audio file. It generally depends upon whether the person is untrained or trained. The untrained person usually compares two tunes and makes observation whereas trained musician will recognize the raga based upon its intrinsic characteristics like pakad, arohana-avarohana, gamakas, choice of swaras, vadi, time, season etc. Arohana-Avarohana pattern denotes the ascending and descending order of swaras respectively. The word pakad, used in Hindustani classical music, means "grip" or "to catch." The pakad of a raga contains the smallest combination of notes, through which we can identify raga. Gamakas refers to embellishment that is used in the performance of Indian classical music. Vadi is defined as the most important swara in a raga. Each raga is related to particular season of year and time. These are main features of raga [8].

Kumar, V., Pandya, H., & Jawahar [6] used SVM with pitch class profile and n-gram histogram and got 83.39% - 97.3% accuracy. Koduri G. K., Gulati S., & Rao P [7] used K-NN with pitch class profile and got accuracy of 76.5%. Sharma, H., & Bali, R. S. [2] have used Fuzzy logic with pakad, time, vadi, distance and achieved accuracy of 75.6%. Pandey, G., Mishra, C., & Ipe, P. [4] used Hidden Markov Model with pakad matching and n-gram matching and got accuracy of 77% for HMM only and 87% for both HMM and pakad matching.

From this review, we get the idea of which classification algorithms and features will be suitable for classification of Indian classical music.

Classifier	Features	Accuracy	References
HMM	Pakad Matching, n-gram matching	77% for HMM 87% for both HMM and pakad matching	[4]
K-NN	Pitch Class profile	76.5%	[7]
Clustering Algorithm	Frequency ratio	Vocal 80% Instrumental 85%	[10]
Bayesian Classifier	Pitch class profiles	82%	[3]
SVM	Pitch class profile and n-gram histogram	83.39%-97.3%	[6]

Random Forest	Swara Histogram	94.28%	[11]
Fuzzy Logic	Time and season, pakad, vadi, distance.	75.62%	[2]

Table 1. Related Work

IV. EMOTIONS

Emotion is any brief sensible experience categorized by acute mental activity and a high degree of happiness or unhappiness. According to some theories, they are a state of feeling that results psychological and physical changes that affect our behavior. Emotion is also related to behavioral tendency. Extroverted people are probably to be social and convey their emotions, while introverted people are probably to be more socially reserved and hide their emotions. According to other theories, emotions are not creative forces but simply malady of components, which might include feeling, motivation, behavior, and physiological changes, but no one of them is the emotion.

Rasa	**Bhavas**
Shringara	Rati(love)
Hasya	Hasya (mirth)
Adbhuta	Vismaya (astonishment)
Shanta	Shanta (calm)
Raudra	Krodha (anger)
Veera	Utsaha (energy)
Karuna	Soka (sorrow)
Bhayanaka	Bhaya
Vibhatsa	Jugupsa (disgust)

Figure 1: Rasa with Bhavas

Emotions in Hindustani Classical Music are defined by nine swaras. The above figure shows the Rasa-Bhava model, which defines the emotions related to each rasa. The Hasya rasa represents Hasya (humor and happiness). The Shringara rasa represents Rati (love). The Adbhuta rasa gives Vismaya, which is the feeling of wonder and surprise. The Vibhatsa rasa generates Jugupsa (disgust). The Bhayanaka rasa represents Bhaya (fear). Karuna rasa corresponds to Soka (sadness). The Raudra rasa corresponds to Krodha (Anger, Wrath). The Veera rasa represents Utsaha (energy). The Shanta rasa represents Shanta (calmness, serenity). In Hindustani Classical Music each rasa gives different types of emotions. These Rasas are related to specific Ragas in Hindustani Classical Music. Following table shows mapping of Rasas with Ragas.

Rasa	Raag
Shringara	Kafi, Yaman, Basant, Pilu, Khamaj, Bageshri, Bhairavi, Sohani, Des, Tilang, Tarana, Hamsadhwani, Zinzoti
Hasya	Pahadi, Dhani, Bahar, Tilakkamod, Khambawati, Malhar
Karuna	Jogiya, Ramkali, Kalingada, Bhairavi, Sohani, Marva, Todi
Raudra	Shankara, Bhup, Puriya, Malkauns, ShuddhaSaranga, Bahar
Veera	Shankara, Hindol, Kedar, Patadeep, Kamod, Malkauns
Bhayanaka	Shree, Deepak, Malshree, Jaitashree, Jait
Bibhatsa	Music with improper tonality
Adbhut	Basanta, Bahar, AlhaiyaBilawal, Parameshwari, Bhairavbahar, KaunsiKanada
Shanta	Bhairav, Bhairavi, DarbariKanada, Multaani, Bhimpalasi, Purvi, Jayjaywanti

Table 2. Raga Rasa Relation

V. TEHNIQUES FOR RAGA IDENTIFICATION

In this section, we are going to present a survey of existing system dealing with the raga identification with their different approaches, implementations and issues regarding these systems.

1) SVM (Support Vector Machine) approach:

Kumar and Pandya [6] looked into the problem of raga identification in Indian Carnatic music. Based on the observation, presented methods are either based on n-gram histogram or pitch-class profiles of notes but not both, they tried to include both of them in a multi-class SVM framework by linearly associating two kernels.

Each of these kernels captures the similarities of a raga based on n-gram histogram and Pitch-class profiles of notes. Pitch-class profile corresponds to the distribution of pitch values; n-gram distribution gives the information about the occurrence of short sequences of notes. They use Comp-Music dataset consisting of 170 tunes equivalent to 10 ragas and achieve an enhancement of 10.19% in accuracy.

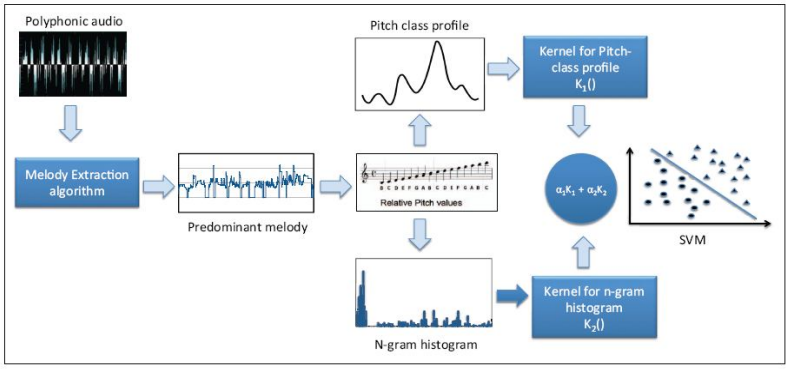

Figure 2. Raga Identification Using SVM Classifier

They achieved 83.39% accuracy for pitch class profile and 97.3% for n-gram histogram.

2) K-NN classifier:

Koduri G. K., Gulati S., & Rao P, introduced a raga classification experiment and presented results on the comparative work of the various types of pitch-class profiles for varied classifier settings. An appropriate dataset is composed from commercially available CD audio recordings. They use leave-one-out cross validation with a k-NN (k Nearest Neighbors) classifier to calculate the performance of their system to get best result and got 76.5% as an overall accuracy [7].

3) HMM:

Pandey, Mishra, and Paul proposed 'Tansen' system based on Hidden Markov Model and Pakad matching with test data for two ragas Bhupali and Yaman kalian. HMM model is used because swara sequence for a raga is familiar and notes are minute in number.

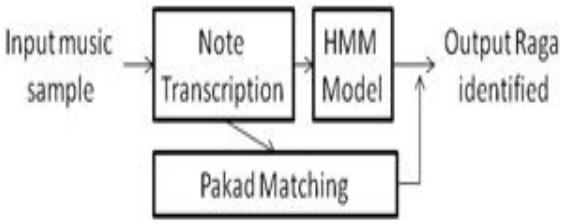

Fig. 3: HMM model and Pakad matching system.

This system consists of note transcription step, which is completed through two heuristics for converting input audio into sequence of notes. Two heuristics are The Note Duration Heuristic based on considering constant duration and occurrence of a note and The Hill Peak Heuristic based on hill and peak value detection in pitch graph. There are two ways for pakad matching as δ-Occurrence with α-Bounded Gaps in which individual note from piece is matched with notes in sample to calculate score with condition that:

- There should be maximum difference of $\boldsymbol{\delta}$ between current note of sample p and next coming note in piece t.
- Position of existence of note t in sample p is displaced at most by value of α.

and N-gram matching which count frequency of successive n-gram of input string with pakad kept in database to found score. Both of these scores are used for final recognition of raga. This system has achieved accuracy of 77% with plain HMM and 87% with both HMM and pakad matching method with only two ragas [4].

4) Bayesian classifier:

Sharma, Panwar and Chakrabarti used an analytical approach for determining the *raga* which was based on feature extraction using naïve Bayes algorithm and Expectation maximization algorithm. It used the frequency component, low level features like zero cross validation, spectral roll off points etc with the variation of the pitch frequency, timber parameters, high frequency components, low frequency components etc for recognition of *Ragas.*
The *Weka* tool and the *Jaudio* open source tool for the simulation have been used in this study including the Matlab programming environment and toolbox for the effective result simulations.

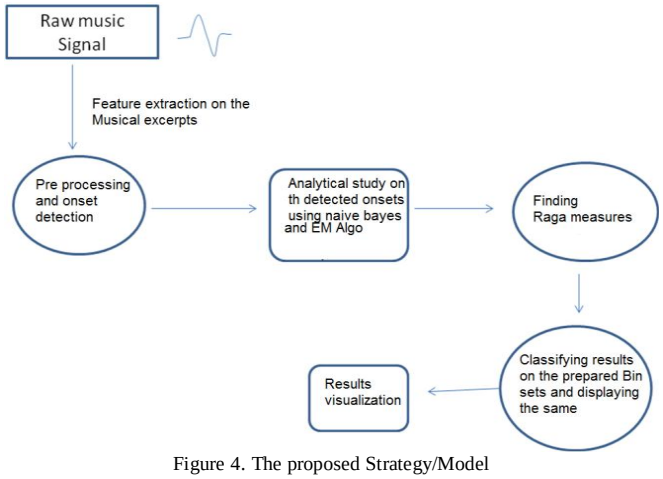

Figure 4. The proposed Strategy/Model

This system has achieved 70% accuracy for Expectation Maximization algorithm and 82% accuracy for Bayesian classifier [9].

5) Fuzzy Logic:

Hiteshwari Sharma and Rasmeet S. Bali proposed a method for identification of raga based upon fuzzy logic. Fuzzy logic deals with reasoning which is approximate. Fuzzy membership functions have been used and estimation is done. The results show that certain level of uncertainty still leftovers, as the values are averaged and approximate. They used dataset of five ragas and average values are calculated by recurrent sampling of each raga about 20 to 30 times and are examined for three parameters as time, dirga swaras and vadi. Analysis shows that for most of the traditional Indian ragas, identification can be accomplished with reasonable accuracy using the proposed technique and the time taken for identification is within acceptable limits.
They used Soft computing techniques for recognition of raga. This work demonstrates a modified approach by combining parameters of music with soft computing. Raga recognition has been analyzed through soft computing and evaluation of the proposed technique shows that reasonable accuracy has been achieved [2].

6) Clustering Algorithms:

Prithvi Upadhyaya1 and Shreeganesh Kedilaya B proposed a system, which is capable of identifying the Raga in any pitch of the audio file, known the pitch frequency in which the music is rendered. The input in the wave format is sampled first to reduce the data size. It is then filtered with a low pass filter to remove high frequency noise. Then the audio samples are segmented.

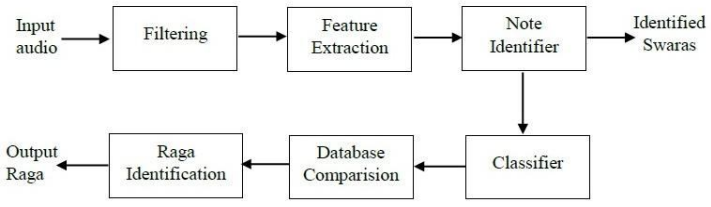

Figure 5. Flow Diagram of the proposed system

They used pitch detection algorithm to find pitch frequency foe each segment. Knowing the base frequency of the input, the system is designed to calculate the relative frequency to find the notes present in the audio sample. Hence knowing the notes, the algorithm uses clustering method for classifying the Ragas by counting on the number of pitch frequencies obtained, for each of the note. Hence, the classifier uses the clustering algorithm. Ones we get the various notes present, it will be compared with the database present. The Raga to which it best suites will be the output Raga.
They achieved 80% accuracy for vocal signals and 85%accuracy for instrumental signals [10].

VI. CONCLUSION

A brief introduction about raga and its characteristics are discussed. Previous techniques for raga identification are surveyed with their dataset, implementation method details, accuracy and issues. The techniques differ from each other with difference in their dataset, implementation method, parameters, accuracy and limitations. Using classifiers we get identified raga, so we can correlate this raga with its respective rasa to identify emotion in music.

From all these classifiers we can conclude that with SVM classifier it is difficult to handle scale and multiple instruments. With K-NN classifier more comprehensive dataset is needed for better result but it may give problem for gamakas and pitch extraction. With HMM, constraints are quite restrictive, if we give improved base frequency for audio sample and improved multiphonic note identification for audio sample then performance of HMM will increase. With Naïve Bayes classifier, raga identification is very difficult and gives less accuracy. With Clustering algorithm, nearby ragas cannot be detected and system can be enhanced by using robust classifier. With Fuzzy logic, certain level of uncertainty remains. We can only get approximate values using soft computing techniques such as fuzzy logic.

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